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THESIS

TECHNOLOGY STRATEGY INTEGRATION

by

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Techno-strategic integration is the process through which militaries integrate technological advances into a strategy that maximizes their advantages. While sheer military might is a function of a variety of factors, technology has taken center stage in the past two centuries. The industrial revolution changed the way war was fought; and the changes had wide ranging effects. The calamity of the First World War was in some ways a failure to techno-strategically integrate industrial age technology. The history of military technology and strategy illustrates many obstacles to the integration of the two. This thesis shows that successful techno-strategic integration is often highly correlated with effective execution of war and improvement of national security. On the other hand, enduring organizational preferences, inter-service rivalry, and commercial self-interest have often undermined new techno-strategic possibilities. However, with the growth and increasing capability of information age technology, this research shows growing indications that the techno-strategic paradigm of the industrial age is shifting. The United States is positioned to capitalize on its lead in informational innovations, and integrating technologies into new concepts of operations. If managed successfully, the United States might emerge with a leaner, more agile force that can keep its strategic competitors at bay.

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TECHNOLOGY STRATEGY INTEGRATION

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ABSTRACT

Techno-strategic integration is the process through which militaries integrate technological advances into a strategy that maximizes their advantages. While sheer military might is a function of a variety of factors, technology has taken center stage in the past two centuries. The industrial revolution changed the way war was fought; and the changes had wide ranging effects. The calamity of the First World War was in some ways a failure to techno-strategically integrate industrial age technology. The history of military technology and strategy illustrates many obstacles to the integration of the two. This thesis shows that successful techno-strategic integration is often highly correlated with effective execution of war and improvement of national security. On the other hand, enduring organizational preferences, inter-service rivalry, and commercial self-interest have often undermined new techno-strategic possibilities. However, with the growth and increasing capability of information age technology, this research shows growing indications that the techno-strategic paradigm of the industrial age is shifting. The United States is positioned to capitalize on its lead in informational innovations, and integrating technologies into new concepts of operations. If managed successfully, the United States might emerge with a leaner, more agile force that can keep its strategic competitors at bay.

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LIST OF ACRONYMS AND ABBREVIATIONS

AEF	American Expeditionary Force
ARVN	Army of the Republic of Vietnam
ASDIC	Allied Submarine Detection Investigation Committee
ATGM	Anti-Tank Guided Missile
BuAER	Bureau of Aeronautics
BuOrd	Bureau of Ordnance
CAS	Close Air Support
CAP	Combined Action Program
CIDG	Civilian Irregular Defense Groups
CIGS	Chief of the Imperial General Staff
CNO	Chief of Naval Operations
DARPA	Defense Advanced Research Project Agency
GPS	Global Positioning System
IAF	Israeli Air Force
IDF	Israeli Defense Force
IED	Improvised Explosive Device
GWOT	Global War on Terrorism
JSOC	Joint Special Operations Command
MAAG	Military Assistance Advisory Group
MACV	Military Assistance Command Vietnam
MAD	Mutually Assured Destruction
MoD	Ministry of Defense
NSC	National Security Council

NTC	National Training Center
OIF	Operation Iraqi Freedom
RAF	Royal Air Force
RMA	Revolution in Military Affairs
SAC	Strategic Air Command
SAM	Surface to Air Missile
SAS	Special Air Service
SOF	Special Operations Force
U.S.M.R.R.	United States Military Rail Road
VC	Viet Cong
WWI	World War I
WWII	World War II

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I. INTRODUCTION

The tools of war both fascinate and horrify with their elegance and killing prowess. International power derives from a complex relationship between economic, diplomatic, informational, and military factors. In the military arena, prowess is often equated to technological "superiority." Although states can rise and fall in relation to the power of their militaries, the relationship between military power and technology is sometimes hard to specify. Clearly, examples such as Vietnam show that technological superiority is not sufficient to ensure victory; however, it is also true that failure to equip a military with technologically sophisticated weaponry can lead to defeat. Furthermore, military technology, and the arms industry that supports it, can represent an almost limitless portion of a state's expenditure. Deciding on what technology to invest in, therefore, is a crucial element of strategy.

In order to explore the interaction of strategy and technology, defining these key concepts of is in order. Strategy itself is hard to pin down. Grand strategy, as conceived by Barry R. Posen and others is an overarching construct that looks holistically at how a state can secure itself and contains military, economic, and political means.[1] Posen further stipulates that military doctrine, a subset of grand strategy, deals with answering questions regarding what means a military will use, and how they will use them.[2] A similar characterization of strategy is offered by Arthur F. Lykke Jr., who in turn attributes it to remarks made at the U.S. Army War College by General Maxwell D. Taylor. Lykke breaks strategy down in to three components: ends, ways, and means.[3] Whereas, strategy as defined by Joint Publication 1–02 (Department of Defense Dictionary of Military and Associated Terms) as "A prudent idea or set of ideas for employing the instruments of national power in a synchronized and integrated fashion to

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[1] Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca: Cornell University Press, 1984), 13.

[2] Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars,* 13.

[3] Arthur F. Lykke, "Toward an Understanding of Military Strategy," in *U.S. Army War College Guide to Strategy*, eds. Joseph R. Cerami and James F. Holcomb, 2001), 179.

achieve theater, national, and/or multinational objectives."[4] The main difference inherent in these three sources is the macro distinction between grand strategy, and strategy. Grand strategy occurs at the national level, and encompasses decisions made in both peacetime and while engaged in conflict that pertain to security. Strategy, in terms of the conduct of a campaign, is narrower, and operates as a component of grand strategy. Strategy describes the local mixture of ends, ways, and means for victory. Technological decisions, for the most part, fit into the arena of grand strategy. As former Secretary of Defense Donald Rumsfeld said, "you go to war with the Army you have."[5] Rumsfeld's quote suggests the underlying importance of making the right technological choices while at peace, but technology can also be developed and adopted during war. How do technological choices get made? What influences affect adopting new, or maintaining old technological paradigms?

A. THE RESEARCH QUESTION

This study starts with the following question: what is the relationship between strategy and technology in military affairs? The term Revolution in Military Affairs (RMA) has become so commonplace that it may have lost some of its meaning. It is time to look more fully into the critical relationship between technology and strategy.

Stephan Biddle highlights two macro positions that characterize how technology's relationship to military power has been investigated. First, there is systemic theory, which looks broadly at technological forms from a standpoint of their relationship to offensive and defensive employment, rather than from any specific technology's superiority.[6] Systemic theory is useful when it highlights how advances in one area lead to advances in another opposing area; a persistent feature of arms spirals and races. However, the systemic position is weakened, to some degree, by the multipurpose use much of today's technology is capable of—the distinction between offense and defense,

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[4] Dept. of Defense, *Joint Publication 1–02: Department of Defense Dictionary of Military and Associated Terms*Department of Defense, 2010), 323.

[5] William Kristol, "The Defense Secretary we have," *Washington Post*December 15, 2004.

[6] Stephen D. Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, N.J.: Princeton University Press, 2004), 15.

particularly in "irregular" warfare, is just not as clear as systemic theory requires. The second view, dyadic theory, accounts for some of the problems identified with systemic theory. Dyadic theory looks at the quality and quantity of technology, and explains victory in terms of technological superiority.[7] Like the systemic position's adherents, dyadic theorists have trouble incorporating accounts where technologically inferior foes have defeated their superior adversaries. Biddle acknowledges that both the systemic and dyadic theories are insufficient based on their implicit technological determinism, which, among other things, masks the importance of force employment, troop morale, and will.[8] Force employment enriches the characterization of a military's performance beyond technology into areas such as doctrine. Furthermore, force employment includes a broad category of characteristics, such as, leadership, morale, training, and experience that influence military operations, but are separate from technology.[9] Part of the reason Biddle gives for the general lack of attention to force employment, is the difficulty it poses to military modelers who primarily use equations derived from technological information in their simulations.[10] Biddle acknowledges the difficulty of modeling force employment, but also indicates that military professionals have long included it in their assessments.

The idea of force employment is critical to unlocking a fuller, less deterministic, account of the relationship between technology and strategy. While both systemic and dyadic theory emphasize the importance of technology, the force employment position looks more deeply at both the technological and human factors that influence military effectiveness. Biddle's central thesis is that the modern system, which is characterized by combined arms formations and requires decentralization to lower echelons of command, was developed by WWI and has not been supplanted.[11] Horowitz and Rosen challenge Biddle's thesis on the grounds that the metrics that define the modern system,

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[7] Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, 16.

[8] Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, 19.

[9] Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, 17.

[10] Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, 18.

[11] Michael Horowitz and Stephen Rosen, "Evolution Or Revolution?" *The Journal of Strategic Studies* 28, no. 3 (June, 2005), 440–441.

such as, dispersion, firepower, and maneuver are sufficiently present in all combat. Therefore, using them to evaluate the adoption of the modern system does not clarify what variables are really important.[12] Horowitz and Rosen provide clarity by supplying a definition. "An RMA is a combination of new military organizational goals and structures with new operational practices on the battlefield that are sometimes but not always driven by technologies."[13] This definition avoids the determinism inherent in the systemic and dyadic theories, and captures Biddle's key insight of the importance of force employment while avoiding his limited metrics.

Complicating the characterization of a time period as "revolutionary" are the inevitable disputes regarding the delineation of dates. The demarcation critique is a persistent criticism echoing back to the first formulation of a military revolution by Michael Roberts in the 1950s. However, the enduring elegance of Roberts's initial formulation and its persistence both speak to the appeal of the idea. Roberts's developed the idea of a military revolution when he began studying the sweeping changes in Sweden from 1560–1660. Geoffrey Parker succinctly summarizes Roberts's thesis along four themes: 1. Tactics; 2. Strategy; 3. Scale; and, 4. Societal impact.[14] Tactically changes in infantry and cavalry formations and maneuver required a more thoroughly trained soldier, capable of fulfilling their role in concert with the larger formation.[15] The process of training soldiers in particular was important; it was through the participation in standardized drill that soldiers became a relatively uniform product.[16] As noted by William McNeill, they became "replaceable parts of a great military machine."[17] Given the larger initial investment in training a competent soldier, states were reluctant to disband their forces upon the conclusion of a campaign; therefore, changes in tactics

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[12] Horowitz and Rosen, *Evolution Or Revolution?*, 443.

[13] Horowitz and Rosen, *Evolution Or Revolution?*, 441.

[14] Geoffrey Parker, "The "Military Revolution," 1560–1660--a Myth?" *The Journal of Modern History* Vol. 48, no. 2 (June, 1976), 195–197.

[15] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 196.

[16] William Hardy McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Chicago: University of Chicago Press, 1982), 141.

[17] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 141.

precipitated the creation of standing armies.[18] Strategically, a large disciplined standing army created new employment opportunities for a state because these soldiers could be counted on to do their duty in ways that inexperienced troops could not—audacity emerges as a decisive element of strategy.[19] The realization of the new strategic capability of the standing army increased the scope of the possible, thus, to achieve these strategic possibilities armies and campaigns increased in size changing the scale of war.[20] Larger scale wars, accordingly, had a larger impact on society.[21]

Parker's critique challenges Roberts's timeline and location of the early modern "military revolution," showing that many of the changes Roberts uses as evidence preceded 1560, were evident earlier in the historical record, and had taken place elsewhere.[22] However, Parker accepts that a change writ large had occurred in the scale and societal impact of warfare from 1560 to1660. Interestingly, Parker also accords some of the changes in tactics and strategy to technological factors. The increased use of pikes in both offensive and defensive roles displaced the economically more costly heavy knight.[23] "This shift in emphasis from horse to foot was crucial to army size."[24] Parker also notes that administrative, logistical, and economic reforms were all necessary to realize and control larger armies.[25] At the strategic level Parker indicates, in an analysis reminiscent of the systemic position, that during this time the offensive-defensive balance was being redefined by advances in cannonry and fortifications.[26] Cannonry struck the proverbial first blow with advances in casting making current fortifications obsolete, and therefore, favoring offense.[27] Architects in Italy responded by redesigning fortifications

[18] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 196.

[19] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 197.

[20] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 197.

[21] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 197.

[22] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 199–207.

[23] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 207.

[24] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 207.

[25] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 206–210.

[26] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 203–205.

[27] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 203.

a modified form of the venerable bastion—the sharply angled *trace italienne.*[28] The *trace italienne*, nearly impervious to cannon bombardment, necessitated a siege strategy, which neutralized the value of the technologically enhanced cannons, and led, in general, to a stalemate in the heavily fortified areas of Europe.[29] Thus, the changing strategic relationship between offense and defense was responsible for the revolutions in strategy during this timeframe not the growth of trained disciplined forces as indicated by Roberts. In the final analysis, Parker differs only in the details of the course of the early modern military revolution, he acknowledges that fundamentally the scale and societal impact of warfare outlined in Roberts's thesis were indeed revolutionary. Others such as Jeremy Black go further than Parker, and question the validity of defining this historical period as revolutionary at all.[30]

Black, like Parker, focuses on the timeline, and argues that Roberts's thesis minimizes the changes that took place before and after Roberts's 1560–1660 delineation. Specifically, Black notes, "[i]n so far as a military revolution occurred in the early modern period it could be dated more appropriately to the hundred years, especially the first fifty, after the period highlighted by Roberts."[31] However, Black's criticism is more important than a mere quibble over dates. Black suggests that rather than focusing on Swedish tactical innovations, army size, morale, and tactical flexibility were the changes that led to increased proficiency.[32] More importantly, Black turns the process on its head and suggests that rather than the increases in the size of armies leading to the creation of modern states, the emergence of the modern state led to the in the increase in the size of armies.[33] The impetus of this critique is rightfully cautionary, although, it is accurate to correlate the rise of states and the size of armies it is misleading to assess causation in either direction.

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[28] Parker, *The "Military Revolution," 1560–1660-–a Myth?*, 203–204.

[29] Parker, *The "Military Revolution," 1560–1660--a Myth?*, 204.

[30] Jeremy Black, *A Military Revolution?: Military Change and European Society, 1550–1800* (Atlantic Highlands, NJ: Humanities Press, 1991), 6.

[31] Black, *A Military Revolution?: Military Change and European Society, 1550–1800*, 93.

[32] Black, *A Military Revolution?: Military Change and European Society, 1550–1800*, 94.

[33] Black, *A Military Revolution?: Military Change and European Society, 1550–1800*, 67.

As both the initial formulation of the military revolution hypothesis and its subsequent criticism indicates, it is exceedingly difficulty to characterize and demarcate transformational time periods in the historical record. However, it is also true that, to some degree, technology plays a role in shaping our society—there is no critique of Roberts's thesis that denies that warfare has changed. This study will attempt to examine the integration of technology into the existing military framework, and will argue that military effectiveness is, in part, a function of the degree to which the technology a military has is integrated with the overarching conditions for its employment as outlined in a state's grand strategy. Antecedent conditions affecting integration, such as, civil-military relationship, military-industrial relationships, the degree of strategic competition, and the development cycle of technologic innovation, will be considered in their relationship to integration. Finally, since grand strategy is not always clear, and both military professionals and the arms industry are invested in the technological decisions made by a state, the integration of technology is not always as straightforward as one would hope. When discussing technology it is useful to think in terms of three broad archetypes: evolutionary, revolutionary, and imitative.

1. Technological Archetypes

With the observation that the term RMA has lost some of its caché, and the definition supplied by Horowitz and Rosen above, it is time to think more deeply about what constitutes a revolution. Clearly a true revolution cannot happen every day, nor is every new technology revolutionary. However, it does seem that there are times when weapons technology develops in a way that either transcends its previous forms, as in nuclear bombs, or takes on an entirely new form.

The key feature of a revolution is the creation of novelty. But does successful integration of revolutionary technology always lead to increased effectiveness and efficiency? Revolutions, also, are relatively short lived in comparison to the longer evolutionary process. Looking at Thomas Kuhn's characterization of the history of scientific progress outlined in *The Structure of Scientific Revolutions* provided an

accessible and pertinent framework for looking at the progress of military technology, and also provides some insight into the military's organizational difficulties with integrating new technology.

The major distinction at work for Kuhn is between normal science and revolutionary science. During a period of prolonged normal science the details of a governing theory are attended to, leading to an increasingly more complete epistemological description of reality.[34] However, during the process of conducting normal science there will be an increasing amount of inconsistencies that are neither predicted nor explained by the operating framework of the macro theoretical construct within which the experiments are taking place.[35] These inconsistencies are indicative of a schism between reality and the characterization of reality by the overarching scientific theory.[36] As these inconsistencies mount a new paradigm will eventually emerge that accounts for both the inconsistencies, and also incorporates the previous paradigm's explanatory power.[37] Kuhn refers to this as a paradigm shift.

A paradigm shift occurs because of the process of revolutionary science. Revolutionary science is not satisfied with the current paradigm, perhaps, in part due to the growing body of counterfactuals, and offers a new explanatory framework for the description of reality.[38] Interestingly, not all scientists drop what they are doing and get to work filling in the details of the new paradigm.[39] Part of the recalcitrance to adopt the new paradigm is a result of sociological and psychological tension, and Kuhn, in my view, does not develop the social issues thoroughly enough. Robert's, however, in his historical example discussed above is much more prescient in outlining the how social institutions, relationships, and norms can all be altered fundamentally by a paradigm shift. However, our question is how well does this model describe the weapons

34 Robert Klee, *Scientific Inquiry: Readings in the Philosophy of Science* (New York: Oxford University Press, 1999), 202–207.

35 Klee, *Scientific Inquiry: Readings in the Philosophy of Science*, 202–207.

36 Klee, *Scientific Inquiry: Readings in the Philosophy of Science*, 202–207.

37 Klee, *Scientific Inquiry: Readings in the Philosophy of Science*, 202–207.

38 Klee, *Scientific Inquiry: Readings in the Philosophy of Science*, 208–215.

39 Klee, *Scientific Inquiry: Readings in the Philosophy of Science*, 208–215.

development process? Does it adequately incorporate the strength of the evolutionary model, but also, explain the human design process and the organizational resistance present in the historical record?

Normal science is analogous to the evolutionary process of weapons development. The main feature of normal science is the refinement of the paradigm by filling in the details. In evolutionary development the main feature is specialization. Refinement and specialization both narrow the framework—in science this is epistemological and in war it is operationally. Wars occurring during a period of evolutionary development, against a roughly peer competitor, take on an almost game-like quality.[40] Revolutionary technology changes the rules of the game. It creates new operational capabilities.

Just as in science, however, the implications of revolutionary technology may not be realized immediately by the existing military bureaucracy. The military hierarchy, in the case of adaptation, is perfectly suited to fail. All the power at the top of the pyramid came to age in the old paradigm; their identity is defined by their association with the organizational forms, and operational capabilities predicated by the old technology. When a revolutionarily new technology comes into existence, the people in power are the least likely to support the transformation of the corresponding cultural idiosyncrasies and organizational forms the new technology encourages. The catalyst that finally forces transformation is sadly, often calamity—and sometimes even calamity is not enough. Lessons can be ignored just as easily as they are learned the American Army's reluctance to embrace counterinsurgency after Vietnam comes to mind as one example.

Using Kuhn's framework as an analogy for understanding the processes at work in the interplay between evolutionary and revolutionary technological processes is helpful. However, it is also necessary to consider each archetype individually. Making distinctions between different forms of technology is difficult, and, as with any distinction, can be arbitrary.

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[40] Martin Van Creveld, *Technology and War: From 2000 B.C. to the Present* (New York; London: Free Press; Collier Macmillan, 1989), 285–296.

a. Evolutionary

Evolutionary technological development is characterized by a process of continual refinement through a process of incremental change directed at improving performance. Evolutionary development constitutes the majority of military-technological history, is relatively stable, and produces an environment where peer competitors engage in generally agreed upon styles of combat.[41] Evolutionary technology is entrenched in the organizational memory of the military that seeks continually to improve its technology at the margins, without questioning whether the technology renders a decisive advantage. The evolutionary archetype accounts for the majority of technological "progress." This conceptualization of technology excels in explaining the continual process at work in the refinement of a device over a period of time. Evolutionary analogies are also useful in explaining the back-and-forth one-upmanship of arms races.

b. Revolutionary

Revolutionary technology is characterized by the appearance of a significant innovation, or a series of mutually supporting innovations.[42] This can occur as part of a deliberate design and production process, or as the result of cumulative improvements that eventually morph the technology. Revolutionary technology from either process presents a difficult organizational, and doctrinal challenge to integrate, but may offer an advantage if the integration is successful. Revolutionary technology is rare, and the window of opportunity to capitalize on its potential advantages is brief due to the tendency for advantageous technologies to be imitated, and the diffusion that any successful idea or device will naturally enjoy. Consider what the implications could have been if the German Navy had recognized the potential of submarines during the interwar period. It was a revolutionary technology ignored, until it was too late to take full advantage of it.

[41] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 342.

[42] Max Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today* (New York: Gotham Books, 2006), 7–8.

c. Imitative

Finally, the imitating organization, acknowledging that it cannot compete with an adversary's research and development and manufacturing dominance, adopts a strategy to capitalize on the widespread proliferation of technology in general, or actively seeks out and copies proven existing technology in an effort to reduce the opponent's advantage. Imitation can be a valuable strategy. Imitation results from diffusion. Diffusion, as articulated by Everett M. Rogers in *Diffusion of Innovations* is a four-part process that starts with an innovation, which is communicated by various channels over time through individuals in a social system.[43] Moreover, it may be that countries that are late to modernize are able to "inherit" the most advanced technology without the detritus of preconceived paradigms, which, in some cases, promotes greater acceptance and further innovation.[44]

Although there are at times similarities between imitation and revolutionary development, the two are separate based on the distinction between innovation and imitation as it relates to development of technology. In the area of doctrine and organization the imitator may be revolutionary, but in terms of development and production it is imitative. Interestingly, the imitator may at times be more integrated both doctrinally and organizationally with a technology that it did not invent then the inventor.

2. Modeling Relationships

A model can be constructed by placing the degree of integration on the X axis and the type of development on the Y axis as shown in Figure 1.

[43] Everett M. Rogers, *Diffusion of Innovations*, 4th ed. (New York: Free Press, 1995), 35.

[44] Alexander Gerschenkron, *Economic Backwardness in Historical Perspective, a Book of Essays* (Cambridge: Belknap Press of Harvard University Press, 1962), 7–9.

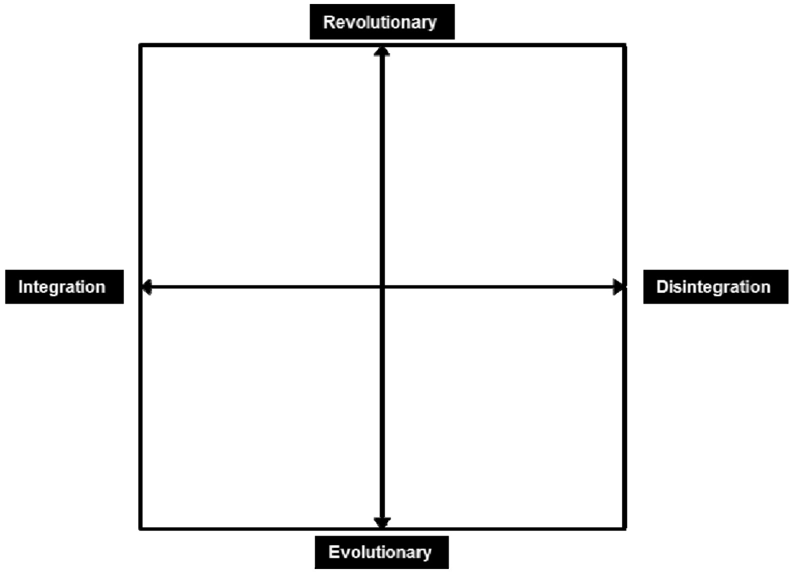

Figure 1. Model showing the degree of integration on the X axis and the type of development on the Y axis.

Four relationships are thus depicted: 1. Revolutionary and disintegrated; 2. Revolutionary and integrated; 3. Evolutionary and integrated; and, 4. Evolutionary and disintegrated. Furthermore, the model can show changes over the life cycle of a piece of technology. Some predicted movements are shown in Figure 2; which shows eight trends inherent in the model. The first four represent stasis, and are operating when a technology remains in its current quadrant. The next four apply to technology over its life span. Also, while imitation is absent along either axis it is still operating, most likely in quadrant three, which represents evolutionary and integrated technology. This quadrant is the most susceptible to imitation because the technology in this quadrant, presumably, has diffused enough to be copied, and has been proven to work within an existing concept of operations.

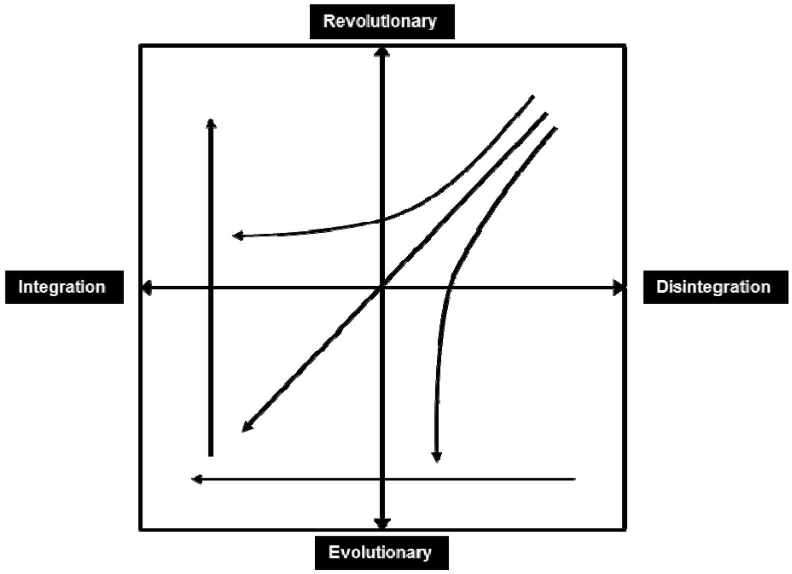

Figure 2. Model showing the predicted trends of technology over its life cycle

Movement from quadrant one to quadrant three is the typical progression. Generally this is the movement that exist when a new technology emerges that challenges the status quo. At first it is unwieldy, but, over time it is assimilated, while simultaneously it is improved and imitated. There is one example of a technology that has moved over the course of its production from quadrant one to quadrant three. Tanks made their debut in 1916 during the Somme offensive in WWI, however, their initial employment was disjointed. Over the remainder of the war the technology evolved and the strategy for their employment was improved by the battle of Amines in 1918 tanks played a decisive role in crushing the German Army. Movement from quadrant one to quadrant four represents when a revolutionary technology emerges that is not integrated, but, yet receives continued support resulting in subsequent generations that are improved but remain disintegrated. Possible explanations for this include collusion between powerful lobby groups and the military, or incongruity between the part of the organization that uses the technology and the one that procures it. The Strategic Defense Initiative could be an example of a revolutionary technology that was disintegrated, and remained disintegrated despite subsequent improvements in its technological foundation. Movement from quadrant one to quadrant two represents the integration of revolutionary technology, while maintaining its revolutionary character. This progression is inherently

hard to achieve, but could in the best case represent an agile military that is quick to realize and integrate the advantages of a new technology. Arming aerial drones, which were initially a revolutionary reconnaissance device, is an example of maintaining revolutionary technological advantages while continuing to integrate. Movement can also be upward. The proliferation of technology into less advanced areas of the world can make technology in a sense revolutionary even if elsewhere it is familiar. The proliferation of AK-47s is one example where a technology may have moved from quadrant three to quadrant two. In this case a seemingly evolutionary technology was reimagined as a central feature in the "irregularization" of warfare in otherwise technologically unremarkable societies. Machine guns are an example of a technology that moved from quadrant four to quadrant three during the course of the First World War. The machine gun contribution to defensive concepts was ignored in favor of the organizational preferences for offensive. During the course of the war the machine gun was integrated into defenses leading to a protracted stalemate on the Western Front. Over time, like all technology the trend is to become evolutionary, but given the absence of having to learn how to integrate a technology, this movement enables a longer period of advantage.

The cycle of invention and counter-invention, and the tendency for older technology to be replaced by new innovations can displace evolutionary technology. This process is reflected in the model as growing disintegration, which is represented by movement, from quadrant three to quadrant four. This constitutes a second order movement, whereby, evolutionary and integrated technology ceases to be demonstrably effective, but is retained. The displacement from evolutionary and integrated to evolutionary and disintegrated, also, may imply that new technology and doctrine is available for adoption. The resulting friction between those who want to maintain the old and those who embrace the new is, potentially, indicative of the conditions that support a paradigm shift or RMA. This friction is again reminiscent of Kuhn, where some scientists continue to hold onto the old scientific paradigm after a new paradigm is presented. One example of this movement might be the continued support for and the

development of battleships in the interwar period when developments in both submarines and aircraft carriers were increasingly making them arguably obsolete, or at a minimum increasingly vulnerable.

3. Hypotheses

This thesis focuses on the conditions under which each type of technological development best serves strategic objectives. In essence this fit is what constitutes techno-strategic integration. To understand these conditions, I will examine the following four hypotheses.

a. Hypothesis 1: Political-military Interactions, Which are Characterized by an Informed and Involved Political Process Positively Affects the Integration of Revolutionary Technology

The military side of civil-military relations can be construed as a continuum marked on one end by traditionalists and the other by progressives. The traditionalists hold that the current force structure, technology, and doctrine are mostly adequate, and consist of the majority of the senior leadership in the military.[45] The other side of the spectrum is marked by progressives, who are interested in exploring new organizational, doctrinal, and technological paradigms. Due to the inherently hierarchical nature inherent of militaries the voices of the progressives, which are traditionally associated with lower rank, are drowned out by the more senior traditionalist.

The political side also contains traditionalists and progressives. Furthermore, the relations between politicians and the military can be construed as a continuum from permissive to restrictive. Permissive relationships are characterized by allowing the military a free hand in its affairs. Under these conditions the integration of revolutionary technology is not expected due to the disparity of power between the mostly higher ranking traditionalists and the younger, lower ranking, progressives. However, under certain conditions, such as when a high-ranking progressive senior leader is empowered within a permissive environment, the integration of revolutionary

[45] John Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military* (Chicago: Ivan R. Dee, 2008), ix–x.

technology is likely to be facilitated. Restrictive relationships, also, may limit the ability of a military to integrate revolutionary technology, perhaps due to, among other things, budgetary constraints. However, a restrictive environment arising from the exercise of civilian control of the military to force change as a response to a new definition of grand strategy may be the catalyst that forces traditionalists to support and then integrate revolutionary technologies. Civilian control of the military, when it is found, implies a responsibility of the civilian leadership to define the grand strategy within which a military can expect to find itself employed. Since grand strategy dictates how and under what conditions a military will be employed, it is therefore inclusive of technological and organizational structuring. Although, a certain degree of inclusion of the military in the definition of grand strategy is expected, acquiescence to the military will be considered as indicative of poor relations. Therefore, political relations defined by knowledgeable and involved politicians will, when necessary, force techno-strategic integration on the military, thus, leading to an increased likelihood of integrating revolutionary technology.

b. Hypothesis 2: Technology Produced Predominantly by a Highly Specialized Weapons Industry, Characterized by Specific and Narrow Product Lines with a Large Investment Overhead, is more Likely to Result in Evolutionary Technology

The other side of civil-military relations is embodied by the relationship between the military and the industrial apparatus that designs, manufactures, and markets the tools of the military trade. As technology has advanced, the investment in the manufacturing equipment needed to produce the technology has grown. This represents a sunk cost to industrialists; one which is recouped if the technology it is designed to yield has a relatively long production span. A long production span is assured if the only change that occurs is in the form of performance upgrades, which do not significantly alter the overall design. One way that industrialists potentially try to shape market forces is to recruit retired military traditionalists, presumably to leverage their ties to the still-active community in support of the company.

c. *Hypothesis 3: Periods of Adversity and Intense Strategic Competition will Increase Pressure to Integrate Revolutionary Technology, Whereas Periods of Stability will Promote the Continuation of Evolutionary Integrated, and Potentially Evolutionary and Disintegrated Technology*

This hypothesis focuses on the antecedent conditions of the security environment within which technology is designed and integrated. In short, not all conflict is created equal. States fight wars for a variety of reasons, the most adverse of which would be a war for existence. A state's perception of its vulnerability is also a component of strategic competition, thus, the perception that a war is imminent can provide motivation to explore new technological forms. It is also possible that once a state has achieved a position of relative dominance, and, therefore, does not feel the necessity of innovation, it will lapse into a period of technological comfort marked by the continued evolution and reliance of the technology that vaulted them to their dominant position past the point of its rendering an advantage. Disintegration is likely when other states, striving for relative dominance, continue to innovate and introduce new technological and doctrinal combinations, which render the older forms obsolete, or develop countermeasures that negate the dominant powers advantages.

d. *Hypothesis 4: Complexity and Exposure to Others' Advances Affect Technological Imitability*

In general, the longer a technology has been around and been employed the more likely it is that it will be copied. However, using length of time as a metric is problematic for a historical case study methodology because increases in global interconnectivity have, in some ways, reduced the time necessary for technological diffusion. Although harder to quantify than time, exposure is more indicative of how imitation proceeds. The exposure of the Soviet Union to atomic technology—through the use of espionage—increased the speed of the diffusion of the atomic bomb to four years. Exposure also explains how interconnectivity has decreased the relative time required for imitation. Reverse engineering of captured enemy equipment, intellectual property theft, or espionage all increase exposure—more exposure equals more opportunity. The second factor, complexity, is also a factor in imitability. Straightforwardly, technology that is

more complex is more difficult to imitate. But, there is also a potential relationship between exposure and complexity, where it is assumed that more complex technology requires greater exposure to imitate. Finally, imitation does not imply that the technology is being used in the same way that designer intended it to be used. The proliferation of munitions designed as artillery, but employed as Improvised Explosive Devices (IEDs) is a prime example of this.

e. Scope

This study will look at the relationship between technology and strategy using the hypotheses above to orient the discussion. I will narrow the scope of this study to the industrial and post-industrial age roughly beginning with the period of history immediately preceding the American Civil War and continuing through the U.S.'s involvement in recent conflicts, such as, Iraq, Afghanistan. The reason for selecting this time period is due to the weapons industries' great impact on the integration of technology and military doctrine in the mass production era.[46] Contextually, factors such as the offensive-defensive balance, technological superiority, and the process of change—whether incrementally, transitionally, or through imitation—will be explored to see the variety of ways that technology has affected doctrine and organizations. Technology strategy will be looked at distinctly to discern the conditions that may favor innovation or imitation in both peacetime and during war.

4. Methodology

Methodologically this study will employ an heuristic approach.[47] This method assumes that broad historical studies are better suited for phenomena when existing theories cannot adequately explain or few existing theories are available.[48] In other words, the heuristic approach analyzes cases inductively in order to arrive at a

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[46] Benjamin A. Taylor, "Military Innovation in the Rise and Fall of Great Powers: Lessons for America" (MS Thesis, Naval Postgraduate School), 1–129.

[47] Harry Eckstein, *Regarding Politics: Essays on Political Theory, Stability, and Change* (Berkeley: University of California Press, 1992), 143–147.

[48] Eckstein, *Regarding Politics: Essays on Political Theory, Stability, and Change,* 143.

preliminary theoretical construct or constructs.[49] This method is critical for exploring techno-strategic interaction because the human variables involved are hard, if not impossible, to quantify. Vignettes will be selected to highlight the process of integrating technology. Furthermore, the heuristic method will allow the search for inductive generalizations, which can facilitate prescriptive recommendations. Policy recommendations will be formulated with a goal toward reducing unnecessary expenditures and increasing the likelihood of a techno-strategic advantage.

[49] Eckstein, *Regarding Politics: Essays on Political Theory, Stability, and Change,* 144.

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II. CASE STUDY: 1840 TO WWI

The impact of the industrial revolution on warfare was felt only gradually during the years leading up to World War I. Throughout the period beginning in the 1840s, accelerating in the 1880s, and coming to horrible fruition in WWI, a series of changes took place that transformed warfare.[50]. The industrialization of weapons manufacture had implications for the relationships between industry, politicians and the military that were not as apparent prior to large-scale, fast pace technological change became possible. Technical innovation at time preceded doctrinal developments; however, much of the character of modern warfare is evident in the historical record as early as the American Civil War (1861–1865).

A. 1840–1914: THE GROWING INDUSTRIALIZATION OF WARFARE

The industrial revolution, with its technological and manufacturing implications, radically altered the tools of warfare in a relatively short time period. However, it is wrong to attribute the carnage of WWI strictly to the appearance of new machinery. Although there were some limited efforts, notably by the Prussians, to integrate new technologies into an overarching cohesive system of warfare, the majority assumed that warfare remained unchanged. How this was possible in the face of examples from the American Civil War, the small wars of British Empire, and the Russo-Japanese War, all of which indicated that fundamentally war had changed, is in itself an indication of the difficulties of techno-strategic integration.

The industrial revolution made larger, better equipped militaries possible, resulting in an increased atmosphere of strategic competition starting in the 1840s, as indicated by a non-comprehensive list of conflict that includes the Crimean War (1854–56); the American Civil War (1861–65); the Franco-Prussian War (1870–71); the Boer War (1899–1902); the Russo-Japanese War (1904–05); and the countless colonial actions of the British Empire. Astute observation of these conflicts should have left little doubt about what the outcome of applying old tactics in the face of new technology would be.

[50] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 223.

Tracing the technological developments in military technology from 1840 through 1914, and comparing their design to both their planned and actual use should provide insight into the difficulties of techno-strategic integration.

1. Armies

Small arms development during the time period from 1840–1914 represents an unusual case where a number of discrete advances in the rate of fire, and accuracy over time culminated in a technological revolution of firepower. Ultimately, small arms, to include machine guns, and the failure to integrate them into a new overarching doctrine, resulted in the tragedy of trenches and frontal assaults in WWI. Tracing the development of small arms through this period shows how a series of seemingly small technological changes may mask the wider implications of an actual technological revolution.

a. Small Arms Development into the American Civil War

The impact of the British and French victory at the siege of Sevastopol during the Crimean War showcased to the world the effectiveness of an army in possession of a superior small arm.[51] While the British charge of the Light Brigade into withering cannon fire during the battle of Balaclava showed the lethality of artillery.[52] Similarly, at the battle of Sinope Russian cannons would decimate the Turkish Navy.[53] The difference highlighted at Sevastopol was the superiority of the rifle over the musket in terms of accuracy—the rifle capable of hitting targets out to 1000 yards to the muskets 200.[54] Rifles did not represent a new technology, but they had generally not been the preferred small arm of field forces due to the difficulty of ramming the shot down a rifled barrel.[55]

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[51] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 231.

[52] Alan Warwick Palmer, *The Banner of Battle: The Story of the Crimean War* (New York: St. Martin's, 1987), 130–131.

[53] Robert B. Edgerton, *Death Or Glory: The Legacy of the Crimean War* (Boulder, CO: Westview Press, 1999), 16.

[54] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 231.

[55] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 231.

This problem was solved in two ways. One solution was developed in 1849 by French Captain Claude-Etienne Minié who developed a round smaller than the bore of the rifles and had a hollow base capable of expanding as the gun was fired, thus, creating a tight seal that allowed the round to bite the grooves within the barrel and impart the spin necessary for accuracy.[56] A second solution developed in Prussia in the 1840s was to change the method of loading from ramming a shot down the muzzle to loading a shot at the breech resulting in the Dreyse breech-loading rifle, or needle gun. However, precision manufacturing was not quite on par with the requirements of an accessible breech that could open to accept a round, and then close with a seal tight enough to channel the explosion well enough for extended range.[57] The needle gun had a range about half of a rifle that fired a Minié ball; however, an advantage of the needle gun was that it could fire seven shots per minute as opposed to two Minié balls.[58] In both cases, the necessity for speedy standardized production and precision tolerances led to the transformation of the arms industry from a tradecraft practiced by skilled craftsman to a mechanized industry capable of mass production.

Efforts to standardize arms manufacture had been underway in America since the 1790s when Eli Whitney, of cotton gin fame, was contracted to produce 10,000 muskets.[59] Importantly, Whitney was attempting to produce a musket standardized to the point that its parts would be interchangeable with any other musket of the same production, a feat unobtainable by a craftsman based manufacturing process.[60] Whitney was unsuccessful in pursuit if his goal, but, importantly, the idea caught on. Mass

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[56] Robert L. O'Connell and John Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present* (New York: Free Press : Distributed by Simon & Schuster, 2002), 191.

[57] Robert L. O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression* (New York: Oxford University Press, 1989), 192.

[58] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 192.

[59] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 182.

[60] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 182.

production utilizing machinery promised to solve the problem of long production times and ensured the precision necessary for uniformity.[61] The birth of the modern arms industry was under way.

Others took up the challenge, such as, John H. Hall, another American, who was instrumental in the adoption of viable machine based weapons manufacturing.[62] Hall developed a viable breech loading rifle and, more critically, a manufacturing process emphasizing machinery and measurement protocols that standardized production.[63] Significantly, Hall's manufacturing techniques were adopted by Roswell Lee and instantiated at the Springfield armory where refinement in the industrialization of arms manufacturing continued to improve.[64] A period of rapid innovation in small arms, spurred by competition for market share, and fostered, in part, by the successful adoption of machine based manufacture descended on the Connecticut River valley in the years just prior to the American Civil War.

Many of the participants in this competition formed companies that are still influential in American Small arms manufacture to this day, or produced weapons that are iconic such as: Colt, Smith and Wesson, Henry, Spencer, and Winchester.[65] Moreover, innovation was not limited to rifles. Significant progress was made in pistols and metallically encased self-contained cartridges. The latter innovation promising to free soldiers from both laborious loading procedures and the storage problems associated with powder.

The Crimean War foreshadowed some of the growing disintegration between small arms technology and military strategy, but the American Civil War,

[61] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 390.

[62] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 390.

[63] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 184.

[64] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 184.

[65] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 184–187.

considered by many historians to be the first modern war, really brought the growing divide into the open. Due to its modern nature many of the variables in this study are clearly evident. Interestingly at the start of the war in 1861 rapid firing repeating rifles utilizing metallically encased munitions, such as the Henry and Spencer rifles, were available; however, both the Union and the Confederacy went to war largely with smoothbore muskets. This would change dramatically over the course of the conflict.

Starting in 1855, based on the conclusion of Jefferson Davis, in his pre-confederate role as secretary of war, the armory at Springfield had been directed to start producing rifled muskets resulting in the Model 1855, and followed shortly thereafter by both the Model 1858 and the 1861.[66] Throughout the war, the armory accelerated production resulting in a total of 802,000 by the end of the conflict.[67] Diffusion, enabled in part by the long development cycle of American manufacturing technology, and England's Enfield Arsenal's hiring of a former Harpers Ferry mechanic and inventor James Henry Burton resulted in the 1853 Enfield Rifle many of which ended up in Confederate hands.[68] Both sides neglected the more revolutionary repeating rifles available. However, the advances in range and accuracy resulting from the use of rifled barrels were more than enough to antiquate the preferred tactics of both sides.

b. Small Arm Techno-strategic Disintegration in the American Civil War

The generals of the Civil War came from various backgrounds, but many had attended West Point in each other's company and had fought together as younger officers in the Mexican War.[69] Officers on both sides adopted strategies that pitted close order linear formations opposite one another—musket tactics for a rifled war.[70] The

[66] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 197.

[67] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 190.

[68] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 189–190.

[69] Martin Dugard, *The Training Ground: Grant, Lee, Sherman, and Davis in the Mexican War, 1846–1848*, 1st ed. (New York: Little, Brown and Co., 2008), 7–36.

[70] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 197.

resulting techno-strategic disintegration, in this instance, resulted in the deaths of 620,000. Had both sides used the better weapons available it is true that the casualties may have been higher, however, it is also possible that if only one side had used better weapons and integrated them into a coherent strategy that the war would have been won more quickly. The disintegration of close order tactics in the infancy of the modern arms industry offers a clear look at one the variables under consideration in this study.

What was the role of civil-military interaction in the integration of new small arm technology? As noted above, Jefferson Davis played a key role in setting the conditions for the adoption of rifled muzzle loading arms. Ignoring the irony and focusing on the more interesting question of why repeating rifles, which were clearly superior in terms of rate of fire, ignored? Furthermore, the Enfield 1853 suggests that the military reluctance to adopt repeating rifles was not confined to North America.

Two reasons for the apparent favoritism emerge. First, the adoption of a breech loading rifle whether holding one shot such as the Sharps and Henry rifle, or the seven-shot Spencer rifle (1862), necessitated tactical adjustments that departed from the organizational entrenched doctrine that had been learned from Napoleonic study, reinforced in the collective Mexican experience, and promulgated in the curriculum of West Point.[71] The preferred strategy emphasized the offensive "assault troops advanced with cadenced step, firing volleys of command and then double-timing the last few yards to pierce the enemy line with a bayonet charge."[72] Breech-loaders allowed soldiers to load from the prone, and could, therefore, lead to a breakdown of the close order formation.

The second reason for ignoring the superior breech-loading rifle was concerns over the increased consumption of ammunition that would accompany the higher rates of fire. This concern was clearly operating in the mind of Union Chief of Ordnance General James W. Ripley who resisted President Lincoln's urging to adopt

[71] James M. McPherson, *Battle Cry of Freedom: The Civil War Era*, Vol. 6 (New York: Oxford University Press, 1988), 473.

[72] McPherson, *Battle Cry of Freedom: The Civil War Era*, 473.

breechloader for as long as possible.[73] General Ripley's concern may have had some merit; however, it seems that he not only failed to grasp the revolutionary impact that a rapid-firing, breech-loading rifle would have on the battlefields across America, he also, failed to realize the impact of the revolution in the manufacturing process that had occurred to meet these demands.

Moreover, President Lincoln's personal involvement in a trial of both the Spencer and Sharps rifle is an indication to the degree that civil military relations were at work during the American Civil War. Lincoln was notably interested in "machinery and gadgets," and spent time throughout the war investigating new inventions—anything that promised to bring the war to a more expedient ending.[74] Perhaps if Lincoln's suggestions had been more forceful, or his attention more focused, he could have accelerated the adoption of the repeating rifle for the entire Army and not just select units such as Colonel Hiram Berdan's sharpshooter regiments.[75]

Other variables such as the influence of strategic competition, and specialized weapons industries do not figure into the American Civil War's narrative of techno-strategic integration as it pertains to small arms. Primarily this is due to the absence of a period where strategic competition could have taken place since both sides in this conflict were united up until the outbreak of hostilities. Furthermore, the arms industry was still relatively new, and had not yet diverged into an industry that solely supported militaries—many of the innovations coming out of the Connecticut valley were available, and necessary to a nation with a broad and largely ungoverned frontier. This would soon change. Working machine guns, notably the American Gatling gun patented in 1862, were on the horizon in the twilight of the Civil War. Gatling guns were not adopted by either side during the war, presenting further evidence of the difficulty militaries have recognizing the potential of new weapons. They would become small arms technology that would solely be under the control of the state, and that would only be at home on the battlefield. As the machine gun developed, the arms industry that

[73] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 129.

[74] David Herbert Donald, *Lincoln* (New York: Simon & Schuster, 1995), 431–431.

[75] Bruce Catton, *Glory Road* (Garden City, N.Y.: Doubleday, 1952), 179.

supported militaries began to take on the specialization that would eventually lead to more incremental evolutionary changes, but in the time period between the American Civil War and the Franco-Prussian war the arms industry was still moving at an exceptionally fast pace.

c. Small Arms Development on the Continent

True strategic competition was taking place in Europe. As a result the pace of arms development was accelerated. In a relatively short time three wars occurred: first the Second Schleswig War between Prussia and Austria against Denmark lasting 10 weeks from February to October 1864; next the Austro-Prussian War lasting seven weeks from June to August 1866; and finally, the Franco-Prussian War lasting just under a year from July 1870 to May 1871. The Prussians adoption of the breech-loading needle gun, its impact on military effectiveness, and the resulting imitation and diffusion were apparent.

An example of successful techno-strategic integration of breech loading rifles through civil-military relations is presented by the Prussians who adopted the Dreyse needle gun by monarchical decree in the early 1840s[76]. The Prussian military correctly recognized the need for new tactics to incorporate both the ability to load and fire from the prone position, and to enforce the conservation of ammunition and set up a six-month training course to instruct the officers and non-commissioned officers in the proper use of their new small arm.[77]

Technically inelegant, the needle gun's only real advantage was its high rate of fire. Furthermore, the nearly three decades it took to equip the Prussian army with the needle gun, and its demonstrated effectiveness in the short wars of the 1860s, ensured that other nations would imitate, and improve upon, its design.[78] Moreover, the now established "American" practice of manufacturing would greatly expedite the process for

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[76] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 196.

[77] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 252.

[78] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 197.

other nations. Both France and Britain took note of the needle gun and followed suit. In 1866 the French adopted the Chassepot. The British, lacking the pressure of a common border with Prussia, made due by modifying their Enfield rifles to breechloaders while a more technically advanced solution was sought.[79] Industrialization made it possible for France to complete the switch to Chassepots in four years in stark contrast to the nearly 30 it had taken Prussia to convert to the needle gun.[80]

Machine gun development was also taking place. The American Gatling gun and the French *Mitrailleuse* were roughly developed simultaneously starting in the early 1860s. However, the Gatling gun saw little action in the American Civil War, while the *Mitrailleuse* was purposely kept so secret that the French army did not possess enough awareness of it to integrate it effectively into their doctrine. As a result the *Mitrailleuse* resembling cannon was employed alongside artillery, which by this point decisively outranged it.[81] It was a mistake that could have been easily prevented had the French experimented more thoroughly.

The decisive victories enjoyed by the Prussians during the 1860s through 1871 were in part a result of their techno-strategic integration of a breech-loading rifle and their adoption of tactics that supported it. There were other reasons that Prussia dominated warfare in this time period, which will be discussed below, but for now the story of small arms needs to be finished.

The back-and-forth development that was starting to characterize small arms manufacture going into the Franco-Prussian War as a result of imitation is indicative of a transformation from revolutionary technological development to evolutionary development. Once the effectiveness of breech-loading rifles was shown by the contrast of the American Civil War and the three quick Prussian victories, nations had little choice but to join in the “small” arms race. Furthermore, the now established

[79] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 197.

[80] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 199.

[81] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 209Arms men 209.

"American" manufacturing techniques, and the requirements for companies large enough to equip an army in a relatively short time specialized the small arms industry enough to engender incremental evolutionary progress of small arms.

Rapid changes were still occurring, but now instead of radically changing the very nature of individual small arms, the changes were garnered more toward perfecting the now established paradigm. Innovation continued to increase the rate of fire from the combined effect of self-contained metallic cartridges, and a series of solutions to develop a way to store multiple rounds effectively. The Prussians adopted the first repeater by retrofitting the Mauser Model 71 (1871) in 1884 with a tubular magazine reminiscent of the Winchester repeating rifle.[82] The English small arms innovator James Paris Lee developed a separate solution—metallic magazines.[83] This necessitated a switch from the single shot breech loading Martini-Henry adopted in 1869 to the Lee-Metford rifle in 1888, and finally, to the iconic Lee-Enfield in 1895. The service length of the Lee-Enfield 1895 to 1957, and its nearly similar counterpart in all of the countries that would fight in both world wars, is indicative that the evolution of small arms was reaching its apex.

Machine guns were still developing. The most significant development took place in 1885 when American innovator Hiram Maxim released the "Maxim" Machine Gun.[84] In reality the Maxim was the first true machine gun. Unlike the *Mitrailleuse* and the Gatling gun, the Maxim gun capitalized on advances in powder technology that enabled the gun to cycle the next round by using the gas from the explosion of the previous round achieving rates of fire between 400 and 500 rounds per minute, barrel temperature resulting from this rate of fire was mitigated by an outer

[82] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 199.

[83] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 199.

[84] Kenneth Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle* (New York: Prentice Hall Press, 1986), 40–41.

casing filled with water.[85] Another significant improvement embodied by the Maxim gun, and in contrast to its predecessors, was that the Maxim weighed in at about 50 lbs. making it entirely portable.[86]

The Maxim was decisively employed at Omdurman on the second of September 1898. Both Winston Churchill, as a correspondent for the *Morning Post*, and General Herbert Horatio Kitchener as commander in chief, were present at the battle. Sadly, it seems that the lesson being taught that day was missed by both men. Churchill acknowledged the impact of the Maxim

> The empty cartridge-cases, tinkling to the ground, formed small but growing heaps beside each man. And all the time out on the plain on the other side bullets were shearing through flesh, smashing and splintering bone; blood sprouted from terrible wounds;…The charging Dervishes sank down in tangled heaps.[87]

Initially there were 52,000 dervishes to the 20,000 commanded by Kitchener; however, due to the effectiveness of the Maxim, the dervishes suffered 10,800 killed and 16,000 wounded as opposed to the British force that lost 48 killed and 382 wounded.[88]

As is typical, the advantages enjoyed by the British were short lived; diffusion would ensure that they too would find themselves on the receiving end of machine gun technology. The British got their first taste soon after Omdurman during the Boer War (1899–1902) at Spion Kop on 24 January 1900. Winston Churchill was again present, although not on the hill top.[89] Also, the Germans, noting the power of the Maxim during a demonstration in 1888, obtained the requisite licensing and began

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[85] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 41.

[86] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 41.

[87] Winston Churchill as cited in Niall Ferguson, *Empire: The Rise and Demise of the British World Order and the Lessons for Global Power* (New York: Basic Books, 2003), 268.

[88] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 167.

[89] Ferguson, *Empire: The Rise and Demise of the British World Order and the Lessons for Global Power*, 272–273.

manufacturing their own Maxims in 1892.[90] To further ensure the guns integration, the Germans instantiated a four-gun battery in every Jäger battalion, and by 1908 the Maxim was standard issue for every German regiment.[91] Continued improvements would be made to machine guns, but for the most part, by the turn of the 20th century the revolution was over. Machine gun technology would soon reach its limitations and modern machine guns are only marginally better than the ones developed either going into or coming out of WWI. Indeed, the Browning M2 .50 caliber machine gun was designed in 1918 and is still in service today, and the life span of the venerable and ubiquitous AK-47 has no end in sight.

d. Artillery Development and Integration

Advances in small arms were not the only changes in weapons development taking place from 1840 going into WWI. Artillery was also undergoing a massive transition. Many of the variables under consideration are more clearly visible in the history of artillery than they are for small arms because there is no convolution between what was being developed for the use of the state as opposed to designed for use by the private citizen. Therefore, the state's role in the integration and diffusion of technology is clearer.

All areas of artillery were simultaneously improved during this time period in a series of advancements in material, design, shot, propellant, and recoil mechanisms. Furthermore, artillery advancements were not confined strictly to land but were also taking place as part of the large naval technological overhaul occurring during this time. During the Crimean War, in a naval action between the Russian and Turks in the port of Sinope, the Russian's cannon improvements decisively outrange the Turks leading to a rout.[92] The Franco-Prussian War would further spur the development of cannons. As William McNeill notes, "after the Franco-Prussian War of 1870–71, armies

[90] Ferguson, *Empire: The Rise and Demise of the British World Order and the Lessons for Global Power*, 270.

[91] Ferguson, *Empire: The Rise and Demise of the British World Order and the Lessons for Global Power*, 270.

[92] Edgerton, *Death Or Glory: The Legacy of the Crimean War*, 16.

too found themselves swept into the vortex of a rapidly evolving artillery technology. In that war, Prussian breech-loading steel guns outclassed the bronze muzzle-loaders with which the French entered the fray."[93]

Artillery development proceeded as part of the overall industrial revolution taking place broadly in the west. In the same vein as the innovators in small arms, advancements in other industrial fields were applied to weapons manufacture. However, two notable differences emerge. First, unlike with small arms, most artillery development took place in Europe. Second and in part explaining the first, artillery development is more exclusively evidence of the state's war-making capacity. Therefore, unlike small arms, which was necessarily a ubiquitous feature of America's frontier expansionism, artillery more clearly reflects the strategic competition occurring in Europe during this time. Successful industrialist from other areas, such as William Armstrong in 1854, decided it was time for military armament to be modernized.[94]

Armstrong's foray into artillery produced a new manufacturing process that utilized composite design, whereby; reinforcing metal was wound around the core and then encased in a heated outer shell that was subsequently cooled to exponentially increase inward barrel pressure.[95] Rifling and a primitive breech loading mechanism were also part of Armstrong's design. However, it was the resulting increase in strength from the composite manufacturing technique which ultimately set the Armstrong cannon apart. The newly minted strength was necessary to take advantages in propellant technology that were occurring during this same time period. Also, the spin imparted by rifling, and the development of integrated fuses, made it possible for munitions designed to explode on impact.[96] The biggest weakness in Armstrong's design was in the breech, which was based on a threaded end cap and, therefore, cumbersome to operate.

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[93] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 242.

[94] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 201.

[95] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 201.

[96] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 201.

The French, adopting the manufacturing process and rifling, but dispensing with the breech, developed a new genre of muzzle loading cannons by 1865.[97] However, the simple solution to ram a shell down the muzzle was a short term fix. The desire to take advantage of propellant technology and barrel strength gave way to an evolutionary progression of barrel lengths, which by 1880 reached the point where it was no longer a reasonable solution to load down the muzzle—breech loading was the only viable option.[98] Meanwhile, the main strategic competitor to England and France was pursuing a different track.

Prussian artillery development can largely be attributed to the resolve of a single individual: Alfred Krupp.[99] Krupp's foundry, rather than relying on a composite manufacturing technique, approached the problem of barrel strength by developing a technique that allowed barrels to be cast from steel. Interestingly, the superiority eventually shown by Prussian artillery in the France-Prussian War would not have been predicted based on the initial civil-military relations between Krupp and the Prussian Officer Corps, which remained largely aristocratic and untrusting of the developing middle class.[100] In 1847 during one initial interaction between Krupp and this antagonistic military hierarchy—the Artillery Test Commission—a steel cannon delivered for testing by Krupp was left in the weather to rust for two years only to finally be tested and, although found superior, Krupp was informed that only bronze would be suitable.[101] Krupp was undaunted and took his cannons around the world selling then to any interested party, thereby, ensuring the diffusion of his technological advancements.[102]

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[97] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 201.

[98] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present,* 201.

[99] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 204.

[100] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 246.

[101] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression,* 205.

[102] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression,* 205.

The nature of Prussian civil-military relations was also moving in a favorable direction for Krupp when, in 1858, Wilhelm I came into power and soon thereafter began modernizing the army through his chief administrator Otto von Bismarck.[103] The new civil-military order decided to equip the army with the needle gun, and to order 300 of Krupp's cannons.[104] Both decisions represented a break from tradition, and neither may have been possible without the direct intervention from the highest authority in the Prussian state.

By the Franco-Prussian War, as a result of strategic competition both sides had made revolutionary advancements in the range of their artillery. Whether by composite manufacture or casting, each side had significantly strengthened their barrels to the degree necessary to take advantage of the advances in propellant technology and fuses. The relatively long development cycle combined with the deliberate expositions and foreign sales ensured that going into the conflict there was relative parity in cannon capability.

However, the Prussians had two advantages. First, their extremely cohesive civil military relations following Wilhelm's ascension accelerated the Prussian procurement process. Second, the Prussian army's recent wartime experience against the Austrians had shown them that the doctrine relevant for the employment of bronze cannons was obsolete. The range enabled by the new artillery required new tactics—it needed to be integrated. The Prussians integration proved lethal "As a result French troops found themselves distracted by long-range bombardment as they were trying to form into columns for the attack… whereas the more open order favored by the Prussian infantry gave the French gunners nothing comparable to shoot at."[105]

Recoil was still an issue. If it could be eliminated than a battery would be able to fire successive rounds on a target without having to take time to reset the gun. Krupp tried to solve the problem by developing a mounting mechanism in 1875 that

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[103] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 246–247.

[104] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 247.

[105] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 251.

prevented recoil, but this solution was untenable.[106] The French, however, pursued a more enduring solution borrowed from designs in Belgian hydropneumatic brakes.[107] The result was the *Mademoiselle Soixante-quinze* in 1897, which was capable of accurately launching 15 75mm shells up to five miles in a minute.[108] The French showing the same penchant for secrecy that they had with the *Mitrailleuse*, closely shrouded the design and performance of their new artillery piece.[109]

By the turn of the twentieth century, advances in artillery began to take on a decidedly more evolutionary character as can be expected from a "large-scale industry, full of sunk costs and huge investments in research and development that might or might not pay off." [110] Governments were struggling to determine how to limit the diffusion of the technologies produced by their native industrialist that negated their own advantages. In 1891 87 percent of Krupp's cannons were sold internationally; government subsidy to arms manufacturing resulted in a system of fiscal patronage that further contributed to evolutionary advancements.[111]

2. Industrial Infrastructure

"Industrialization altered the nature and production of weapons, the transport of troops and supplies, and the methods of communication. It increased the complexity, scope, scale, and lethality of warfare."[112] Modern industrial methods have already been shown in their relationship to the development on small arms and artillery. However, in

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[106] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 205.

[107] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 206.

[108] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 206.

[109] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 206.

[110] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 203.

[111] O'Connell and Batchelor, *Soul of the Sword: An Illustrated History of Weaponry and Warfare from Prehistory to the Present*, 203.

[112] Geoffrey L. Herrera and Thomas G. Mahnken, "Military Diffusion in Nineteenth-Century Europe," in *The Diffusion of Military Technology and Ideas*, eds. Emily O. Goldman and Leslie C. Eliason (Stanford, Calif.: Stanford University Press, 2003), 217.

isolating those two areas of manufacture it must not be forgotten that industrialization was broadly occurring across all sectors of manufacturing. Furthermore, increasing industrialization was impacting political as well as social transformations in all areas of life. Some areas, such as, communications and transportation may not have been specifically driven by military considerations, however, once they were developed their military expediency could not be ignored. As states and their militaries grappled with integrating the diversity of technological forms emerging from the industrial revolution, between 1840 and the outbreak of WWI, a shift in doctrine was also occurring.

Through a process of tactical necessity when troops faced more capable weapons and through the deliberate harnessing of the mobilization and communications advantages of the industrial revolution, the Napoleonic system was replaced by the Prussian.[113] America also faced these challenges, and interestingly developed some of the same solutions, although, as noted by William McNeil, "European military professionals felt that they could safely disregard the American experience of war."[114] Moreover, the evidence that in nearly similar technological situations armies were developing similar approaches highlights to some degree the relationship between technology and strategy and the resulting process of techno-strategic integration.

a. Land Doctrine

Officers on both continents during the time between 1840 and 1914 began the time period with a Napoleonic concept of operations. Industrialization's influence on mass production and technology resulted in sweeping improvements in the areas of small arms, artillery, transportation, and communication. Over time these improvements made the Napoleonic concepts increasingly obsolete. Although both "American" armies showed some learning during the course of the Civil War, in the end the generals were too wedded to the Napoleonic concepts that comprised their formal education and Mexican War experience. General Winfield Scott had translated Napoleon and subsequently written on infantry tactics—one of the junior officers in his command was a

[113] Herrera and Mahnken, *Military Diffusion in Nineteenth–Century Europe*, 205–206.

[114] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 242.

fellow Virginian Robert E. Lee.[115] America's post war drawdown, and renewed focus on the various small wars of the frontier expansion prevented a close examination of some of the lessons coming out of the American Civil War. On the continent, however, the repeated and frequent success of the Prussians left little doubt that warfare had fundamentally changed. The Prussian fusion of military power, in part facilitated by their early adoptions of numerous small arms and artillery technologies, and their co-opting of the industrial architecture of railroads for mobilization and telegraphs for communication was soon adopted by all.

b. Transport and Info-Systems

Railways and telegraphs were, as noted by Martin van Creveld, "two technologies not only developed simultaneously but often did so at the hands of the same people."[116] The link between the two is explained as a function of synchronization—a synchronization that required a "system-approach for its operation."[117] The system required preciseness to be effective. Factors such as the synchronization of time keeping, the regulation of speed, de-confliction of track usage, the standardization of track gauge, and setting the location of nexus depots all depended on the abilities of planning and communication.[118] Furthermore, although neither technology was designed by the military for military use, both were readily perceived by militarist as conferring advantage. By the 1840s militaries were beginning to conduct maneuvers to determine what impact railways could have for warfare.[119]

The initial advantage was with the French who adeptly employed a rail-based logistical system in the siege of Sebastopol during the Crimean War, and later managed to move 250,000 soldiers into Italy during the War of 1859.[120] The Prussians

[115] Dugard, *The Training Ground: Grant, Lee, Sherman, and Davis in the Mexican War, 1846–1848*, 10, 293.

[116] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 157.

[117] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 157.

[118] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 157–158.

[119] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 158.

[120] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 158.

were slow to start, and in 1852 their failure to fully integrate rail technology resulted in a botched mobilization and defeat at Olmütz. However, recognizing the importance the railways played in mobilization and the complexity of synchronizing train tables, the Prussian General Staff created the a railway section.[121] This resulted in through integration of the railway into the Prussian concept of operations. Again highlighting the importance of civil-military integration, Herrera and Mahnken note that "The Prussian rail net was no different from the French, or any other…. The Prussian difference was in the way the army coordinated with civilian companies and planned the mobilizations in advance."[122] However, with new capabilities come new vulnerabilities as Union Generals would learn during their militarization of the railway during the American Civil war.

In the relatively early stages of the Civil War, (January1862), Congress gave the president broad powers to oversee the railway as he saw fit for military expediency.[123] To accomplish this, the Union established the United States Military Rail Roads (U.S.M.R.R.), and placed an experienced rail executive at its head.[124] The Confederacy did not follow suit, therefore, the Union was more technologically integrated then the Confederacy in regards to railways. Accordingly, there was a benefit to military effectiveness. The benefit was keenly felt in areas of logistics and troop movement. To be fair though, the Union was somewhat predisposed to logistical superiority due to the primacy the North had given to manufacturing in the pre-war era:

> Northern states had manufactured 97 percent of the country's firearms in 1860, 94 percent of its cloth, 93 percent of its pig iron, and more than 90 percent of its boots and shoes. The Union had more than twice the density of rail roads per square mile as the Confederacy, and several times the mileage of canals and macadamized roads. The South could produce enough food to feed itself, but the transport network, adequate at the

121 Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 222.

122 Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 222.

123 McPherson, *Battle Cry of Freedom: The Civil War Era*, 514.

124 McPherson, *Battle Cry of Freedom: The Civil War Era*, 514–515.

> beginning of the war to distribute food, soon began to deteriorate because of a lack of replacement capacity. Nearly all of the rails had come from the North or from Britain; of the 470 locomotives built in the United States during 1860, only nineteen had been made in the South.[125]

With this caveat in mind the most that can be said is that the North capitalized on their opening advantage through further integration of rail technology.

The South on the other hand, realizing the inherent disadvantages of extended supply train in hostile territory, encouraged partisan operations by passing the Confederacy's Partisan Ranger Act in April 1862.[126] The novel development of cavalry tactics that supported the partisans under command of Confederate Generals such as John S. Mosby, John H. Morgan, and, most of all, Nathan B. Forrest were among the lessons that should have been learned going into WWI; the other being the consequences of accurate long range fire to the offense from a foe in earthen fortifications.

However, the lessons of the American Civil War tended to be dismissed on the continent as amateurish—Liddell Hart would study it closely, but after the First World War. The lessons were also largely forgotten by Americans in the military drawdown that followed the conclusion of the Civil War. Furthermore, the swift Prussian victories throughout the 1860s and against France in 1871 and the lessons "learned" from them dramatically colored the conception of warfare going into WWI. Moreover, the success of Prussia forced other countries to take notice of the Prussian method, and adopt their doctrine as best they could.

3. Navies

The impact of the industrial revolution was also influencing navies. Wooden ships were being slowly replaced by iron, sails were replaced by steam, and, as previously mentioned, the developments in artillery were dramatically affecting naval gunnery. Interestingly, many of the technological developments were slowed or deliberately ignored by naval professionals who, among other things, nostalgically clung

[125] McPherson, *Battle Cry of Freedom: The Civil War Era*, 318–319.

[126] John Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World* (Chicago: Ivan R. Dee, 2011), 101.

to the idea of sails on the high seas. The USS *Monitor* would soon challenge the existing state of naval affairs. The *Monitor* was revolutionary—the design alone entailed 40 patents.[127] The Battle at Hampton Roads would dramatically alter ship design. The process of techno-strategic integration on the seas is in some way even more clear, due to the shipbuilding industries ties to government subsidy and a relatively high degree of manufacturing specialization. Furthermore, the relationship between naval doctrine and equipment manufacturing is somewhat clearer in the era directly leading in to the First World War due to the acceptance of Alfred Thayer Mahan's view of naval influence on international power.

a. The Rise of Battleships

The technological capability of surface ships underwent a relatively rapid transformation during the latter half of the nineteenth century. The history assumes an evolutionarily familiar pattern where advances in one area, such as armor, prompt a corresponding advancement in a contrasting area such as gunnery. Although the net effect of these improvements produced a vastly different warship in a short period of time, the evolutionary character of the changes as a whole nullified any truly decisive advantage as other nations kept pace.

Britain, enjoying and wanting to maintain their relative naval dominance had the most to win or lose based on the technological decisions they made. Therefore, it is not surprising that the majority of evolutionary development occurring during this time was initiated in the shipyards of Britain. Starting in the 1830s, the broilers necessary for efficient naval steam energy became available; although, sails were still required to move longer distances.[128] The Royal Navy, in effect starting the industrialization of naval technology, adopted a paddle wheeled hybrid in 1837; however, paddles presented too great a target to last for long and were replaced by screw propellers by 1844.[129] The

[127] James Tertius deKay, *Monitor: The Story of the Legendary Civil War Ironclad and the Man Whose Invention Changed the Course of History* (New York: Walker and Company, 1997), 2.

[128] Jon Sumida, "The Royal Navy and Technological Change, 1815–1945," in *Men, Machines & War*, eds. Ronald Haycock and Keith Neilson (Waterloo, Ont., Canada: Wilfried Laurier University Press, 1988), 78.

[129] Sumida, *The Royal Navy and Technological Change, 1815–1945*, 78.

Royal Navy was also experimenting with iron construction in the early 1840s; however, iron armor was initially abandoned when the effect of solid shot was demonstrated more effective against it then its wooden contemporaries.[130] The movement back to wood was short lived; by 1855 the French had demonstrated the superiority of armor dramatically during the Crimean War.[131]

By 1858, France was pursuing modernization in the form of armored warships, the British were forced to follow suit.[132] As expected, increases in armor coexisted with simultaneous improvements in gunnery, and developments in both cannon construction, and shell design occurred. In short order, solid shot gave way to exploding shells, and one piece casted muzzle loading cannons gave way to compositely constructed breechloaders. France took the initial lead in the transition to breechloaders in the mid-1860s, but by the 1880s, the Royal Navy had followed suit.[133] The introduction of larger, heavier guns dramatically effected ship design—no longer could guns be mounted broadside. Ships were soon mounting fewer larger guns encased in rotating turrets on the top deck, which necessitated the removal of the iconic vestiges of the age of sail to be removed.[134] The HMS *Devastation* perhaps named with the emotions of the nation's sailors in mind, being the first in 1871.[135] The competition between France and Britain was not exclusive; events in the U.S. Civil war would soon demonstrate the growing disparity between armored and wooden ships.

The Confederacy took the initial lead in the introduction of armor, when it retrofitted the hull of the U.S.S. *Merrimack* captured—and quickly redubbed the C.S.A. *Virginia*—from the Gosport navy yard near Norfolk Virginia in April 1871.[136] In what is

130 Sumida, *The Royal Navy and Technological Change, 1815–1945*, 79.

131 Sumida, *The Royal Navy and Technological Change, 1815–1945*, 79.

132 Sumida, *The Royal Navy and Technological Change, 1815–1945*, 79.

133 Sumida, *The Royal Navy and Technological Change, 1815–1945*, 80–81.

134 Sumida, *The Royal Navy and Technological Change, 1815–1945*, 80.

135 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 34.

136 McPherson, *Battle Cry of Freedom: The Civil War Era*, 278–279.

easily a period of intense strategic competition, the Confederacy, under Union blockade, and lacking navy yards, minus Gosport, needed every advantage. Therefore, they engaged in both revolutionary and imitative techno-strategic innovation.

The Confederacy, spearheaded by their Secretary of the Navy Stephan R. Mallory, a former U.S. senator from Florida, employed a deliberately parasitic strategy that transformed existing vessels into gunboats.[137] Also, in an example of effective civil-military relations Mallory, with a keen understanding of the advantage that a fleet of modern armored battleships presented against wooden ships, sent Commander James D. Bulloch England in 1861 to enlist English shipyards in the Southern struggle. The resulting ships, rather than seeking to annihilate the Union's fleet, occupied themselves as commerce raiders impeding Union shipping and distracting ships from the blockade.[138]

On the revolutionary side, Mallory, expanded the Confederacy's use of mines, which by the end of the war had sunk 43 Union ships and he deployed one of the first submarines, the C.S.A. *Hunley*.[139] Submarines were not yet developmentally ready, and the *Hunley* sank four times, killing its crew each time for the price of one Union blockader.[140] However, revolutionary Mallory's thinking was, without a robust internal manufacturing capacity, the Confederate navy could not rise itself above to the level of nuisance in the Civil war. However, that did not stop the Union from taking note of the potential advantage the Confederacy would enjoy if it alone possessed armored ships, and very quickly the Union pursued its own ironclad development.

The Union, enjoying a huge naval advantage, did not feel any pressure to innovate in shipbuilding, however, once the plans of the Confederacy's armored designs became more or less known, the atmosphere of competition was raised to the a level that the Union could not ignore. The Union navy took manufacturing bids, and settled on two prototypical ironclad designs, which would sail as the U.S.S. *Galena* and the U.S.S. *New*

[137] McPherson, *Battle Cry of Freedom: The Civil War Era*, 314.

[138] McPherson, *Battle Cry of Freedom: The Civil War Era*, 314–315.

[139] McPherson, *Battle Cry of Freedom: The Civil War Era*, 314.

[140] McPherson, *Battle Cry of Freedom: The Civil War Era*, 314.

Ironsides.[141] However, the innovativeness of these ships is marginal, they were standard steam driven ships retro-platted with iron armor.[142] A more innovative design was submitted by John Ericsson, who had a previous and not altogether harmonious relationship with the U.S. navy.[143] Ericsson was, however a known naval innovator whose screw propeller design had played a hand in rendering the paddlewheel obsolete.[144]

Ericsson's design not only incorporated all iron construction, but also included a two gun turret.[145] Furthermore, the low profile design presented a small target to the enemy, while maintaining a reasonably shallow draft and a light displacement combined to give the *Monitor* a solid advantage in maneuverability, as long as the seas were calm, over her southern cousin.[146] Wartime conditions prevented a full series of tests and evaluations, and both the *Monitor* and the *Virginia* were launched within two weeks of each other in late January and early February of 1862.[147]

Given the developmental similarities and the reasoning behind the construction of these two ship, it seems as though they were destined to engage each other, and soon enough this destiny became reality. The eventual dramatic engagement, on the mouth of the James River at Hampton Roads, between these two ships occurred soon after their respective launches in March, 1862.[148] The outcome, although not decisively won in regard to the ironclad participants, was a clear victory of armored design and changed global naval affairs decisively.

The *Virginia* was the first to arrive. Guarding the mouth of the James River were five Union ships. As an example of the pace naval innovation had assumed,

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141 McPherson, *Battle Cry of Freedom: The Civil War Era*, 374.

142 McPherson, *Battle Cry of Freedom: The Civil War Era*, 374.

143 McPherson, *Battle Cry of Freedom: The Civil War Era*, 374.

144 McPherson, *Battle Cry of Freedom: The Civil War Era*, 374.

145 Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 201–202.

146 McPherson, *Battle Cry of Freedom: The Civil War Era*, 374.

147 McPherson, *Battle Cry of Freedom: The Civil War Era*, 375.

148 McPherson, *Battle Cry of Freedom: The Civil War Era*, 375.

three of the ships, (*St. Lawrence, Congress,* and *Cumberland),* facing the *Virginia* were still powered by wind, and, although, they had been the "pride of the navy in the 1840s" they were now relics of the age of sail.[149] By the days end, the other two would be just as outdated. The *Virginia's* first opponent was the *Cumberland* which was sank by ramming after an initial salvo of cannon fire.[150] Next, the *Virginia* turned its attention toward the *Congress*, which was dispatched after shell fire ignited her magazine.[151] However, the *Virginia's* deep draft and the dwindling daylight prevented it from closing in for one final kill of the day when she turned her sights on the *Minnesota*, which had been beached during its maneuvers in the assistance of her sisters.[152] The technology of the *Virginia* was clearly significant in terms of military effectiveness, although, the *Virginia* was hit 98 times; her armor had not been penetrated.[153] The Confederate advantage however, was short lived.

Overnight the *Monitor* had steamed in, and the following day the inevitable clash of the titans began. In an ironic twist of fate, neither side possessed guns with the penetration necessary to score a *coup de grace*, and by the end of day, both ships retired leaving no clear victor except that of iron over wood.[154] The results of the battle between the *Monitor* and the *Virginia* were also felt across the Atlantic leaving the London *Times* to comment that "[t]here is not now a ship in the English navy apart from these two [the *Warrior* and *Ironsides*] that it would not be madness to trust to an engagement with that little *Monitor*."[155] The price of failing to update a navy was clearly demonstrated by the *Virginia's* decisive victory on 8 March. It was also clear that cannon technology had to continue in its evolutionary arms race against armor if ships such as

[149] McPherson, *Battle Cry of Freedom: The Civil War Era*, 375.

[150] deKay, *Monitor: The Story of the Legendary Civil War Ironclad and the Man Whose Invention Changed the Course of History*, 155–156.

[151] McPherson, *Battle Cry of Freedom: The Civil War Era*, 375.

[152] deKay, *Monitor: The Story of the Legendary Civil War Ironclad and the Man Whose Invention Changed the Course of History*, 171–172.

[153] McPherson, *Battle Cry of Freedom: The Civil War Era*, 375.

[154] McPherson, *Battle Cry of Freedom: The Civil War Era*, 376–377.

[155] deKay, *Monitor: The Story of the Legendary Civil War Ironclad and the Man Whose Invention Changed the Course of History*, 221.

the *Virginia* and the *Monitor* were to be countered. As discussed above, developments in cannon technology were already occurring by the time of the American Civil War in Europe. Soon though, the pace of naval change in Europe would outstrip anything that had occurred to date.

As noted by William H. McNeill, Britain's security situation was systematically eroding through the diffusion of military technology by the 1870s.[156] In part the diffusion that precipitated the Royal navy's decreased dominance was generated by the decision, in 1864, to consolidate artillery production solely into the hands of the Woolwich arsenal.[157] Competing firms, such as Armstrong, had no recourse except to court outside sales, and indeed, from 1884 to 1914, that firm sold 84 ships to 12 countries.[158] Moreover, the ships being sold by Armstrong abroad rivaled or even exceeded the capabilities of the current British fleet to the degree that the government was forced to respond by placing contracts to update its force.[159] The resulting situation exhibits a classically evolutionary contest where advances in one area would be offset by advances in a contrasting area in a vicious cycle of marginal capability improvement.

Furthermore, the consolidation of production into Woolwich became increasingly troublesome once advances in propellant technology produced muzzle velocities that necessitated an increase gun barrel length that eventually exceeded what could reasonably be muzzle loaded, and in 1879 the British navy finally made the move to breech loading cannon.[160] This created a problem for Woolwich, which needed to simultaneously transform its production machinery, and, based on metallurgical advancements, its basic construction material from wrought iron to steel.[161] The process was time consuming and the pace was compounded by inter-service rivalry with the army which was ultimately responsible for the Board of Ordnance, and was, in the navy's

[156] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 262.

[157] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 262.

[158] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 263.

[159] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 263.

[160] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 265.

[161] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 265.

opinion, not meeting their requirements quickly enough.[162] By 1884 Captain John Fisher decided that it was time to increase the pressure on the government through a calculated use of the media to incite an outcry for additional naval resources.[163] The *Pall Mall Gazette* obliged, releasing an article entitled "The Truth about the Navy," which attributed its information to a confidential source.[164]

That confidant was in fact Royal Navy Captain John Fisher.[165] Although, in the short term, the result of Fisher's pandering to the media was an increase in production, it also may have limited the government's role of providing oversight. If this were the case, then it is an example of poor civil military relations. The politicians were forced—through public outcry—to take action. Taken in this context it is not surprising that rather than calling for an assessment of the navy's shipbuilding plans, and looking critically at what types of revolutionary designs may now have been possible the politicians, instead, just simply increased the production of the navy's preferred platform—the battleship. The outcry for more ships corresponded with an economic depression presenting the obvious solution to end Woolwich's monopoly and open the nation's shipyard for armament.[166]

As competition was introduced, the jobs created in the arms industry through an increase in government military expenditures began to emerge as a viable solution for tough economic times.[167] Taxes, to pay for the increased expenditure, were collected from the rich.[168] A newly inaugurated military-industrial complex emerged in Britain as a small handful of technologically minded officers worked closely with private industry to churn out weapons desired by an economically depressed population and paid for by the wealthy. As the first five year naval building program was coming to a close

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162 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 268.

163 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 268.

164 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 268.

165 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 268.

166 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 269.

167 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 270.

168 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 270.

in 1889, a bill quickly emerged in parliament to continue the program for another five years. By this time, the political impetus behind increased expenditure was clearly in control and the Naval Defense Act actually ended up allocating more money than the navy had asked for. Strategic competition was also increasing at this time as other countries such as France, Germany, and the United States were in part driven to expand their navies by the extortions of Alfred Thayer Mahan's in his influential book *The Influence of Sea Power on History*, published in 1890. Mahan stressed the importance of controlling sea lines of communication, which in war meant, finding and destroying the enemy's fleet, or at a minimum bottling it up.[169] As other countries entered into the naval arms race the evolutionary advancement of battleships in Britain increased resulting in a perfection of the form—the H.M.S. *Dreadnought*, which was completed in 1906.

This ship was so "advanced" that Germany stopped building ships until it could produce a comparable ship.[170] The immediate imitation of the form itself enabled the long and evolutionary character of the naval arms race in terms of improvements at the margins of performance in the same genera of ship. The *Dreadnought* had some significantly different features than its predecessors. First, speed had been increased by replacing reciprocating engines with turbines.[171] Second, the "Invincible" class was specifically designed for long range gunnery, as such; it was the first class of ship to adopt the all big gun form.[172] Finally, the invincible class used oil to fuel its turbine engines rather than coal resulting in a top speed of 21 knots.[173] Bigger, faster, stronger—the *Dreadnought* and her imitators were perfection in form; they occupied the top of the evolutionary hierarchy, and were presumed to be the answer to controlling the sea. However, another line of technology was developing, one based on negating the

[169] Russell Frank Weigley, *The American Way of War; a History of United States Military Strategy and Policy* (New York: Macmillan, 1973), 175.

[170] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 277.

[171] Sumida, *The Royal Navy and Technological Change, 1815–1945*, 85.

[172] Sumida, *The Royal Navy and Technological Change, 1815–1945*, 85.

[173] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 279.

formidable battleships advantage using speed, surreptitiousness, and torpedoes. Understanding the alternative lines of technological development requires a closer examination of the competing schools of doctrine.

b. Naval Doctrine: Mahan and the Jeune École

Two major schools of thought competed for naval minds in the period between the American Civil War and the onset of WWI. The first—best advocated by Alfred Thayer Mahan in his three part series examining sea power's relationship to national power—centered on a concept of operations that stressed the importance of sea lines of communication and specified the objective of the navy as the destruction of an adversary's fleet.[174] The second major school of thought was being developed in France in the *jeune école,* and advocated a concept of operations pitting smaller faster ships, and eventually submarines, armed with torpedoes against capital ships of the line, commerce, and shore defenses.[175] Each influenced the pursuit of technology in different ways based on the implicit concept of operations that each school engendered.

Mahan's works were based largely on history—largely British history in the age of sail. Published in 1890 the main thrust of Mahan's analysis detailed naval interaction in a time before the prevailing technology of his day had been invented or incorporated into shipbuilding and ordnance manufacture. Britain, the predominant naval power of the time, had the most to lose from the changing techno-dynamics of naval power, and, therefore embraced Mahan's analysis concentrating their shipbuilding efforts on using the technology of steam and cannon to replace their ships but not to reexamine their role. At first, Britain's numerous colonies and domination of the coal market provided the means to transition to a coal powered navy.[176] Later, when ships transitioned to oil, Britain was faced with a new vulnerability—oil in wartime would

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[174] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 173.

[175] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000,* 263.

[176] Bernard Brodie, *Sea Power in the Machine Age; Major Naval Inventions and their Consequences on International Politics, 1814–1940* (Princeton: Princeton University Press, 1941), 115.

have to be imported.[177] Other nations, seeking parity with Britain's command of the seas, followed suit. Surface ships came and went quickly in the resulting arms race. However, it was an arms race governed by evolutionary development, and imitation. Although a contrasting approach emphasizing the asymmetry posed by a more revolutionary integration of the new technologies of torpedoes and submarines had been formulated, it was relatively ignored—for now.[178]

c. Different Strategy, Different Ships

The main technological contrast to the battleship was enabled by the torpedo, which by hitting a ship below the waterline negated the advantage of armor.[179] The torpedo required a delivery system, and a variety of forms emerged, all existing to negate the power of the battleship. Torpedoes got off to a relatively slow start, making their first appearance in 1864 as a result of the musings of an Austrian naval captain. They were subsequently championed by an English engineer Robert Whitehead; however, initial performance was slow and erratic.[180] Underwater propulsion, stability and accuracy all were increased as solutions ranging from hydrostatic depth regulators to gyroscopic rudder controls were worked out by various interested parties.[181] By the early 1900s the torpedo presented a true threat and could travel at speeds approaching 29 knots.[182] Furthermore, the distances they could travel reached 18,590 yards by 1913.[183] Range was a critical issue for a weapons system designed to neutralize a battleship whose all-big-gun construction made them capable of ranging out to 35,000 yards.[184]

Adversaries', seeking to neutralize the naval dominance Britain was fighting so hard to maintain, recognized the inherent usefulness of the torpedo. Admiral

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[177] Brodie, *Sea Power in the Machine Age; Major Naval Inventions and their Consequences on International Politics, 1814–1940*, 118.

[178] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 220–221.

[179] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 220.

[180] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 220.

[181] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 220.

[182] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 221.

[183] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 284.

[184] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 281.

Theophile Aube in the *jeune école* and others theorized that reliance on foreign trade and the interconnectedness of global shipping had revived commerce raiding as a decisive form of naval warfare.[185] The conclusion was to build a navy centered on ships that were capable of closing quickly and delivering their torpedo. Torpedo boats thus emerged onto the naval scene by the 1850s.[186] Admiral Raoul Castex, another French naval theorist, also questioned how important control of the sea was for wars between states that were accessible to each other by land—command of the sea was important only if it enabled effective land operations.[187] While commerce raiding was not new, its theoretical resurgence and the technology it necessitated were decidedly more revolutionary than the evolutionary routine that had developed in the battleship arms race. Not surprisingly, torpedo boats were met with scorn; however, the threat could not be denied and various countermeasures developed.

Ultimately, the task of interdicting torpedo boats required the creation of a class of ship designed to defeat them giving rise to the torpedo boat destroyer. With the sanctuary of the battleship preserved inside an illusion of safety provided by its screening force of destroyers, subscribers of Mahan's tenets went back to work building navies capable of crushing their foes in decisive battles for the control of the high seas. However, a better method of delivery was soon to become technically viable, one that would make the best of the torpedo's ability to be fired underwater by being underwater itself—the submarine.

In the years that followed the C.S.A. *Hunley's* demise during the American Civil War, the technology that supported submarines had progressed to the point of viability. John P. Holland, newly immigrated to America from his native Ireland, was largely responsible for developing a modern submarine.[188] Holland, while

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185 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 221.

186 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 221.

187 Raoul Castex and Eugenia C. Kiesling, *Strategic Theories* [Théories stratégiques.] (Annapolis, Md.: Naval Institute Press, 1994), 48, 50–51.

188 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 222.

working for Sinn Fein to design a vessel capable of countering the British, constructed the *Fenain Ram* in 1881, which was capable of deliberately diving and could fire a torpedo while underwater.[189]

By 1900, Holland had solved some of the problems running a combustion powered engine underwater by developing a hybrid engine that ran on battery power while submerged and a combustion engine while surfaced.[190] The union of torpedo and submarine seemed to offer a solution to counter the threat of battleships. Technologically, the submarine represented a revolutionary form as evidence, in some ways by the stark contrast between it and its chief rival the battleship. Battleships operated on the surface, capitalized on might, and sought to engage their quarry in the age old naval tactic of crossing the "T," whereby, they would be able to make maximum use of their guns in destroying the enemy in depth while simultaneously limiting the enemy from hitting them. Submarines, in contrast, operated below the surface, capitalized on stealth, and sought to engage their targets from the side to maximize the effects of a torpedo strike on the enemy's hull.

Given the opposites involved, it is not surprising that the naval establishment, particularly in countries that had set sail with Mahan and embarked in a battleship building frenzy, found it hard to integrate the submarine effectively into the existing naval order. Even after Holland produced a design capable of traveling twice the distance the U.S. Navy had specified, the establishment still balked at the idea of the submarine performing an oceanic role, and instead, based on the testimony of Admiral George Dewey to Congress in 1900, looked to the submarine as a costal defense platform.[191]

The response from the other contenders in the naval arms race was decidedly imitative. Although, Britain, Japan, and Germany would all continue to develop submarines, none would divert more than a fraction of money and effort away

[189] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 222.

[190] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 222.

[191] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 222.

from their battleship programs. While the torpedo had shaken the naval establishment—the U.S. Naval War College acknowledged by 1909 that torpedo attacks would likely prevent a battle fleet from closing into effective range—the submarine remained, for now, a revolutionary and disintegrated technology at the fringes of acceptance.[192] Grand Admiral von Tirpitz notes in his post-WWI memoires concerning his pre-war philosophy "of waiting to prove the military usefulness of a new invention before adopting it universally."[193] Later, Tirpitz abdicates responsibility for not realizing the potential of the submarine before the war, arguing that that would be "the same as to demand that the army should have prepared some defence against the tanks in time of peace."[194] Clearly Tirpitz is conflating his argument since the tank had not even existed before the war while the submarine was available for anyone willing to push on the boundaries of naval thought. However, the implicit faith of navies worldwide in the battleship's ability to sail out and meet the opposing fleet remained resolute. It was a faith predicated on both fleets desiring to enjoin in battle; a condition that would not be realized during WWI.

Although the naval action in the straits of Tsushima during the Russo-Japanese war, from February 1904 to September 1905, seemed to confirm Mahanian theory, and therefore validated an all-big-gun battleship building plan; the reality was that half the ships sunk during the course of the conflict were the result of mines.[195] Furthermore, there had been serious problems with accuracy on both sides as gun range exceeded optical range finding ability.[196] The real reason for the Japanese victory, which was largely dismissed, was that Admiral Togo, using wireless command and control technology, had simply out-maneuvered his Russian counterpart.[197] The battleship was

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[192] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 222.

[193] Alfred Peter Friedrich von Tirpitz, "Building the Fleet," in *My Memoirs*, Vol. 1 (New York: Dodd, Mead and company, 1919), 179.

[194] von Tirpitz, *Building the Fleet*, 180–181.

[195] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 226.

[196] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 53.

[197] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 53.

too integrated into the fabric of the naval establishment to be challenged by small nuisances such as actual combat performance—the answer, for now, was to build them bigger.

4. Summary

On the eve of the First World War there were some mounting inconsistencies in techno-strategy. Small arms, cannon and machine gun advancements had reduced the effectiveness of massed close-ordered formations. Railways had changed time-distance analysis in the areas where there were sufficient rail lines to move troops. Telegraphs and other communications advancements were exerting pressure on methods of command and control. At sea, there had been a series of technological innovations that were causing debate amongst naval strategist about what the best choices were to maintain sea control. Although there were some examples of how these technological advances had changed the effectiveness of some of the older favored strategies, none were seriously reformulated going into the First World War.

III. WWI

The technology available at the outset of the First World War was predominantly evolutionary in character, and the process of integrating it had for the most part, been occurring since the American Civil war. In hindsight it is clear that the net effect of this technology promoted the strength of the defense over the offense; however, organizational preferences among the military traditionalists of the day incorrectly calculated that the offense had been strengthened. The result was a suite of technology that was perceived as integrated but was, in reality, "disintegrated." Over time, the innovation on the western front would reconcile the misperceptions and integrate the technology, but the price in the process of integration would be high. Also, new revolutionary technology would appear, as the stark strategic competition of war is predictive of new technological ideas. Indeed, toward the end of the WWI, offensive concepts of operations become plausible through the integration of tanks on one side, and through the reformulation of small unit tactics supported by machine guns and artillery on the other. At sea, the old paradigm of controlling the sea lines of communications would be tested as naval strategic calculations changed due to the impact of submarines. In other theaters, and often fighting as an economy of force, alternative concepts of operation would show that sometimes the best offenses are conducted *against* the techno-strategic integration of an adversary.

A. DOCTRINE

The successive Prussian victories starting in the 1860s—enabled by the integration of technological changes in rifles, artillery, telegraphs, and railroads into a cohesive strategic doctrine orchestrated by the general staff—spurned others to imitate them both technologically and organizationally.[198] Although complete imitation of the Prussian system was not possible due to inherent social differences between innovators and adaptors, Herrera and Mahnken note that by WWI "the diffusion of German military

[198] Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 205.

methods produced armies that at least superficially resembled one another."[199] Certainly, it is true that the armies in the spring of 1914 were equipped similarly, but the degree of integration varied. The Germans—who originated the system—were the most integrated, they had successfully both adopted and integrated the new technology resulting in tactical, operational and administrative changes.[200] Interestingly, France at the time was at the forefront of technological development and had been the first to use the railroad for military mobilization as early as 1859.[201] However, France failed to integrate the industrial age technology at the organizational and doctrinal level to the same degree as the Germans, who had also benefited from the reflection inherent in late modernization in their imitation and innovation of some of France's early forays into rail mobilization.[202] However, in the execution of the Schlieffen Plan, the Germans may have miscalculated. The further they moved into France, the closer the French were to their logistics, and the more quickly they could reposition against German offensive efforts. The importance of civil-military relationships in the integration of revolutionary technology is evident by the fact that railroads in both France and German were controlled by civilians, but only the German general staff coordinated and planned for mobilizations with the civilian railroad representatives.[203] However, the integration of industrial age technology also created dissonance amongst militaries in their perception of the offensive-defensive relationship.

How is it possible that offensive concepts of operations were accepted in spite of evidence to the advantages of defense? There were contrasting concepts of operations to choose from, such as those of Ivan (latter Jean de) Bloch who, writing in advance of the Russo-Japanese War 1904–05, had concluded that war in the face of recent technological advancements rendered decisive engagements obsolete.[204] Unfortunately, Bloch's arguments were overshadowed by others, notably Colonel Charles du Picq, whose

[199] Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 206.

[200] Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 219.

[201] Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 229.

[202] Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 222.

[203] Herrera and Mahnken, *Military Diffusion in Nineteenth-Century Europe*, 222.

[204] Michael Howard, "Men Against Fire: The Doctrine of the Offensive in 1914," in *The Lessons of History* (New Haven Conn.: Yale University Press, 1991), 97–98.

writing in *Battle Studies* reaffirmed the older more organizationally palatable paradigm of drill, mass, and morale.[205] The cavalry retained their swords and hoped for a valiant charge, and the infantry kept their bayonets so as to imbue them with the force of will necessary to close with the enemy. Both arms would soon find themselves deadlocked in a maze of trenches.

Meanwhile, traditionalists such as Ferdinand Foch evaluated technologies like machine guns and artillery as increasing the power of the offense.[206] The successes of Japanese frontal assaults in the Russo-Japanese War (1904–1905) were misinterpreted as validating the traditionalist idea that highly trained and disciplined troops could overcome the technologies of machine guns and artillery.[207] However, the real lesson of the Japanese assaults was that infiltration, using a series of successive defensive positions could bring you close enough to your enemy that small dispersed teams might have a chance at closing the distance.[208] Military leaders in England, Germany, and France inaccurately cited Japanese victory as sanctifying the offense lead their armies to war in the summer of 1914. But did the offensively minded military lead their countries to war in 1914, if so to what degree, and what does that tell us about the role of civil-military relations and the integration technology and doctrine?

Stephan Van Evera argues that the German obsession with offense underwrote the Schlieffen plan, which famously called for quick and overwhelming attacks into Russia, Belgium, and France.[209] France, also swept into offensive fervor, developed “a single formula for success, a single combat doctrine, namely, the decisive power of offensive action undertaken with the resolute determination to march on the enemy, reach and

[205] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 17–18.

[206] Howard, *Men Against Fire: The Doctrine of the Offensive in 1914,* 98.

[207] Howard, *Men Against Fire: The Doctrine of the Offensive in 1914,* 108–109.

[208] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 18; Howard, *Men Against Fire: The Doctrine of the Offensive in 1914,* 108–109.

[209] Stephen Van Evera, "The Cult of the Offensive and the Origins of the First World War," in *Military Strategy and the Origins of the First World War: An International Security Reader*, ed. Steven E. Miller (Princeton, N.J.: Princeton University Press, 1985), 59.

destroy him."[210] Both the German Schlieffen plan and its French counterpart—Plan XVII—were based on an incorrect assessment of the offensive/defensive relationship that recent technological advancements in guns, cannon, transportation, and communication inexorably altered. Van Evera, utilizing the strengths of systemic theory, draws a series of conclusions regarding how offensively minded countries interact, and how that influenced the onset of WWI. Specifically, Van Evera concludes that offensive mindedness predisposes countries to five "dangers":

1. Aggressive foreign policies
2. Increased risk of preemptive war
3. Increased attention to shifting force ratios because of the opportunities and vulnerabilities they represented
4. Diplomatic competitiveness
5. Greater enforcement of political and military secrecy.[211]

None of the five factors however, are solely the province of the military—they all require acceptance, and ultimately, imply action from a state's politicians. Jack Snyder takes a closer look at how the general military obsession with offense skewed civil-military relations in favor of the military leading to a calamity of techno-strategic disintegration at the outset of WWI.

Snyder shrewdly connects the military's penchant and the political acceptance of offensive doctrines in Germany and France at the outset of WWI to a combination of organizational preferences on the military side and a lack of oversight on the civilian political side. Militaries prefer offense because offensive strategies enhance the perceived potency of the military, increase the initiative in planning, and provide a solidified doctrinal framework of standard operating procedures for the inculcation of younger soldiers and officers.[212] Therefore, lacking political oversight, military's will

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210 Marshall Foch quoted from Van Evera, *The Cult of the Offensive and the Origins of the First World War*, 60.

211 Van Evera, *The Cult of the Offensive and the Origins of the First World War*, 64–65.

212 Jack Snyder, "Civil-Military Relations and the Cult of the Offensive, 1914 and 1984," in *Military Strategy and the Origins of the First World War: An International Security Reader*, ed. Steven E. Miller (Princeton, N.J.: Princeton University Press, 1985), 129.

trend towards an offensive doctrine. The trending toward organizational offensive preference can, in some cases, even overcome evidence that supports different conclusions. In the case of Germany, the General Staff defeated the offensively dominated Schlieffen plan in a one war game, and shamelessly stacked the deck in others.[213] However, the by-product of an overly offensive military doctrine is that it leads to an exceedingly narrow range of military options because there is only one available response to any and all security questions—attack.[214] German political leaders failed to provide the necessary oversight because matters of military strategy were outside of their purview, and furthermore, they could rest easy because the military had them convinced that when a war came it would be both concluded in the favor of the attacker and short.[215] Surprisingly, civil-military relations in France, although unfolding from antagonism between the military and politicians instead of blind acquiescence, produced similar techno-strategic disintegration.

France is especially interesting in the evaluation of how civil-military relations affect techno-strategic integration for two reasons: First, because civil-military relations following the Dreyfus affair noticeable shifted and second, because senior French officers deliberately used military doctrine as a tool for institutional justification. Prior to the Dreyfus affair, civil-military relations in France were characterized by civil oversight that reflected a mutual understanding between an informed and involved political body and the military. Politicians balanced the desires of their constituency with adequate concessions to military requirements.[216] Skillful politicians such as Léon Gambetta and Charles de Freycinet were able to work with the army to make reforms to the conscription system without making the army feel as though it was fighting to preserve its existence.[217] However, the Dreyfus affair eroded civil-military relations, and exacerbated old fears among the French army that their institution was under attack from

[213] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 109,117.

[214] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 115.

[215] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 125–126.

[216] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 129–130.

[217] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 130–131.

reformist minded republican politicians.[218] Significantly, the promotion system was restructured to give greater control to the war minister for selection at all levels not just the top appointments.[219] The French army's defense against the political inroads to their autonomy was to increasingly favor an offensive concept of operations. The rationale behind the French army's return to an offensively dominated doctrine insulated it from an opposing doctrine which was based on a concept of operations where a strategic defense fought by short–term reservist.[220] It was commonly thought at the time that offense required longer periods of conscript service and a larger dedicated standing army because reservist would lack the discipline needed to close with the enemy in the face of withering fire. French military leaders such as General Joffre were able to wrest control back from republican–minded politicians, but at the cost of recognizing the inherent techno–strategic disintegration between his tools and his offensively informed concept of operations.

The macro techno-strategic position of pre-war France and Germany provides insight. The preponderance of the technology was evolutionary, with the notable exceptions of submarines and airplanes. Most of these forms had existed and had been used in the wars discussed during the preceding chapter. However, through a variety of factors discussed above, the bulk of this technology was mistakenly thought to favor the offense. The perception of von Moltke the Younger, Joffre, Foch and others was that this evolutionary technology was integrated into a comprehensive offensive scheme. They were wrong. In reality, the organizational biases among the militaries and a lack of informed oversight by the politicians of the time were forcing the acceptance of a technologically disintegrated concept of operations. The resulting casualties, general stalemate, and ubiquitous adoption of defensive trenches represent, in this case, what might have been an avoidable cost of integration.

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[218] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 131.

[219] Douglas Porch, *The March to the Marne: The French Army, 1871–1914* (Cambridge; New York: Cambridge University Press, 1981), 69.

[220] Snyder, *Civil-Military Relations and the Cult of the Offensive, 1914 and 1984*, 132.

During the war different integrative strategies were employed with varying degrees of success. German commerce raiding using submarines in contrast to the indecisive employment of battleships, both sides attempting to unlock the revolutionary technology of air power, and a return of cavalry in its new technological form, the tank, must be considered against the backdrop of the unfortunately more common practices of "men against fire" taking place at Verdun, on the Marne, and at the Somme.

B. MOBILIZATION

The rapid mobilization of alliance networks in 1914 by both the Central and Entente powers was accomplished through the diffusion of the Prussian mobilization methods of the preceding century. The techno–strategic integration of rail roads in support of national mobilization was demonstrated decisively in the Franco–Prussian war. Other nations, whether directly involved in the conflict or having studied it, were exposed to the idea and emulated it in their own ways. Rapid mobilization was ensured by the integration of the railroad and the common reserve system of the time, which combined compulsory service and an enduring commitment to return to service in time of war. Moreover, the commonly held belief that the first country to mobilize would enjoy a decisive advantage in the opening stages of a conflict combined with the universal embrace of the offense created the conditions of mistrust that prevented effective diplomacy after the assassination of Archduke Franz Ferdinand on 28 June 1914. Furthermore, extremely weak civil–military relations already highlighted above as contributing to the evolutionary and disintegrated fusion of technology and strategy, were at work behind the scenes in both France and Germany where senior military leaders oscillated between cajoling and deriding their political counterparts into mobilization. Moltke directly interceded, going around his civilian "leaders" and calling his Austrian counterpart directly to urge Austrian mobilization and ensuring Germany's.[221]

[221] John Keegan, *The First World War*, 1 American ed. (New York: A. Knopf ; Distributed by Random House, 1999), 64.

Meanwhile, in France, General Joffre tacitly threatened his superiors that he would not be responsible for their continued delays which by his estimation, would result in 15 to 25 kilometers of lost ground daily.[222]

The deterministic view of technology highlights the mobilization of Europe in WWI as a key example of technology shaping history. However, as always, technology was not operating alone. Clearly masked by a suspension of disbelief at the time, the effectiveness of rapid mobilization and offensive operations decisive in the Franco–Prussian war had been checked by diffusion. Rail technology, so crucial in the mobilization for offensive operations, was just as useful moving men to check an opponent's advance. Within days (28 July 1914–6 August 1914) Austria-Hungry, Germany, Serbia, Russia, France, Belgium, England had mobilized and gone to war, and within weeks, the grandiose plans of rapid capitulation were replaced with the grim realities of static trenches. The trenches themselves, and the fighting that trenches engender, were indicative of the disintegrated character of techno-strategy in the opening phase of the First World War. However, the static defensive character that broadly emerged by the conclusion of 1914 exerted its own pressures on the integration of technology and strategy. Initially "generals on both sides would try to smash through the opposing front" highlighting the intransience of the traditionalist offensive ideal.[223] Toward the end of the war, revolutionary technology and its integration would emerge to break through both the front and the old paradigm, but first, the offensively skewed disintegrated techno-strategy had to be rectified with the defensive realities of the ground campaign.

C. LAND: STALEMATE AND "SHOCK AND AWE"

As with most big wars, the literature on the First World War is vast. Therefore, determining what to address and what to leave to another day is a difficult decision. In

[222] Keegan, *The First World War*, 68.

[223] Bernard Law Montgomery, *A History of Warfare* (Cleveland: World Pub. Co, 1968), 464.

order to draw clarity to the process of techno-strategic integration that was occurring during this war, I will focus my analysis of land operations primarily on the Western front.

On 1 July 1916, the British launched a major offensive at the Somme. The battle would last into November and would leave 450,000 British, 195,000 French, and 650,000 German dead for a gain of six to seven miles.[224] The Somme, both in terms of its scale and historical positioning—roughly the middle of the war—represents an example of how the war was broadly being fought. Also notable for the first appearance of tanks—15 September 1916—the Somme provides a starting point to analyze the integration of some of the new technological forms that emerged as the stalemate continued. Before discussing the Somme, however, a quick summary of the opening stages of the war, the establishment of the existing frontage, and the onset of attrition is needed to contextually understand the carnage of the Somme.

The famous Schlieffen Plan, conceived of by Count von Schlieffen who headed the German general staff from 1891 to 1906 and continually modified by both himself and his successors, proposed a quick campaign in France followed by a subsequent campaign in Russia.[225] Bold in its conception—and its assumption that France would be subdued in six weeks—the Schlieffen Plan was flawed. The German general staff neglected the fact that the further they went into France, the more exposed their lines of communication would be while at the same time shortening France's. Not surprisingly, France was ultimately able to check the German advances by using the same rail technology that the Germans had believed would enable their rapid decisive victory.[226] Furthermore, the Germans' reliance on roads and rail created a new vulnerability to sabotage, which was easily accomplished with dynamite—a technique used with great success in another theater by T.E Lawrence.[227] In short, the French ability to maneuver

[224] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 86.

[225] Montgomery, *A History of Warfare*, 463.

[226] Montgomery, *A History of Warfare*, 463.

[227] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 159–160.

against the Germans using rail and the susceptibility of German logistics to sabotage prevented the rapid capitulation of France and allowed the Russians the time they needed to enter the fight, which they did by late August, further compromising Germany's strategic position.

As the Schlieffen Plan's technological infeasibility became manifest to German field forces at Mons (23 July), Le Cateau (26 July), and Guise (29 July), German First Army Commander Alexander von Kluck altered course and failed to envelop Paris.[228] Failing to take Paris preserved France's ability to both generate combat forces and logistically supply them; furthermore, von Kluck's action exposed his flank, which was attacked forcing his retreat and creating a seam that allowed British forces to join with the French on the Marne.[229] The Germans were repulsed at the Marne and pushed back to the Aisne where they established defenses. Germany proved a quick student of the integration of technology into a defensive schema selecting the high ground, and establishing interlocking entrenchments guarded by barbed wire obstacles ranged by both machine guns and artillery.[230] Both sides in a series of successive maneuvers tried to turn their respective opponents flank in what is known as "the race to the sea," eventually concluding in the first battle of Ypres in October and November 1914. Kenneth Macksey indicts the degree of techno-strategic disintegration "neither side was able to overcome even the semblance of an artillery, machine-gun, wire-entrenched position. The technology of defence defeated the current technique of attack, and with quite appalling loss of life, to reinforce the lesson."[231] By the end of 1914 the iconic trenches were dug separated by a swath of land so foreboding to the soldiers that it came to be known in history as "no man's land." Yet on the Somme 20 months later, the idea that an offensive push could overcome defensive positions was still as firmly entrenched as the defenders themselves.

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[228] Montgomery, *A History of Warfare*, 464.

[229] Montgomery, *A History of Warfare*, 464.

[230] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 69.

[231] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 69.

During the 20 months intervening between Ypres and the Somme, steps were taken to further integrate both new and existing technology in support of an offensive. Modern hand-grenades, such as the "Mills bomb" and the *Stielhandgrante*, both appeared in 1915, also, modernized mortars—especially useful against trenches due to the steep angle of the projectile—appeared on both sides with England going so far as to knight Fredrick Wilfred Scott Stokes for his 3-inch "Stokes" trench-mortar. More insidiously, and foreshadowing the role science would eventually play in the advancement of weapon technology, the Germans employed chlorine gas at the Second Battle of Ypres on 22 April 1915.[232] Although surprised by the first attack, which the Germans failed to capitalize on, the allies quickly improvised countermeasures by placing a pad over their faces, and within a year, produced their own offensive chemical weapons[233] Further chemical developments would continue, and again it was the Germans who were first to innovate producing both phosgene and mustard gas munitions by the end of the war.[234] Although casualty estimates produced by *both* sides' use of chemical weapons number around 1.3 million, neither side was able to gain a strategic breakthrough using chemicals.[235] Furthermore, the demonization and relative abstinence from continued use of chemical weaponry, both then and now, suggests that psychological factors exert pressure on the integration of technology. On the whole, the emergence of the above technologies did not alter the static situation of the front and neither would the British offensive at the Somme.

The British began preparing for a summer offensive at the Somme largely to relive the pressure France was facing from the German's early spring offensive at Verdun.[236] By this point in the war, whether acknowledged or not, both sides were locked in a battle of attrition, however, continued improvements were made in the integration of machine guns and supportive artillery fires—killing had become science

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[232] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 252.

[233] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 253.

[234] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 253.

[235] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 253.

[236] John Keegan, *The Face of Battle* (New York: Penguin, 1978), 216.

and both weapons would come to bear at the Somme. Artillery was seen as the panacea for the problem inherent in attacking a defensive strongpoint over open terrain, and was expected to both clear the wire obstacles to the front of the enemy's trenches, and to essentially bury the enemy alive in their current positions, paving the way for a minimally contested walk across no-mans-land.[237] In a situation eerily reminiscent of Pickett's charge at Gettysburg 53 years earlier, which was preceded by the largest southern artillery barrage of the American civil war, British leaders at the Somme erroneously assumed that artillery could nullify the advantages of well-constructed earthworks. Much had changed in the half century between Gettysburg and the Somme, but some things had not. By 1916 the industrialization of war manufacturing was able to produce 2,960,000 shells for the Somme offensive.[238] Shell uniformity, necessary for a scientific approach to bombardment, was also ensured through the standardization required in mass production, although quality issues remained. Furthermore, range and lethality were decoupled by the increases in accuracy achieved by rifled barrels and conically shaped rounds as well as the exploding nature of the shells themselves. Effectiveness was now a matter of getting rounds on target, and that required an observer.[239]

Organizational inroads towards the scientific techno-strategic integration of artillery were made by the inclusion of a forward observer, whose duties included moving behind the infantry advance to sight and adjust rounds using his field telephone to call in deflection and elevation corrections to the battery. The appearance of this organizational addition was predicated on the advancements made to integrate artillery tactics into a more precise "combined arms" approach. At the Somme, the artillery plan consisted of two phases: First a week long general bombardment designed to destroy the German frontline fortifications and the supporting logistical trenches that allowed the covered movement of men, weapons, and materials from the "safe" rear areas to the front.[240] The

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[237]Keegan, *The Face of Battle*, 218.

[238] Keegan, *The Face of Battle*, 216.

[239] Keegan, *The Face of Battle*, 217.

[240] Keegan, *The Face of Battle*, 217.

second phase was the echeloning of fires in support of the infantry's advance; it is in this second phase that the science and professionalization of artillery integration is manifest. Technological improvements in manufacturing had affected both the areas of supply and quality. This permitted the construction of standardized firing tables specific to both the type of gun and the round.[241] Furthermore, artillery science now enabled guns to be adjusted based on the effects of meteorological factors such as winds, humidity, and temperature.[242] Gun batteries were also increasingly centralized, which when synchronized, allowed for concentrated fires either on a point target or as a linear aggregate across a broad frontage.[243] The technological improvements in guns and munitions enabled a "scientific" understanding of trajectory allowing for a reasonable assurance of range, which combined with the organizational variables of centralization and observer control lead to the appearance of the rolling barrage.[244]

Experimentation with these ideas preceded the Somme but, by the time of the Somme offensive, the faith of the British soldiers in the effectiveness of their army's techno-strategic integration of artillery was total. Still, it was unfounded. Ideally conceived, the infantry would advance just outside of the effective bursting radius of shells landing linearly across the enemy's fortification. Subsequently, the fires would be shifted by the forward observer onto the enemy's second line supporting positions creating the conditions for either a continued attack or for repelling a counterattack. Wire based communication between observer and battery were the weak point in the system. Although radios were appearing on the seas and in the air, they were still too unwieldy for tactical land operations. The default plan in the absence of communication, which was nearly always the case, was for the guns to shift according to a preconceived schedule loosely based on the anticipated rate of march for advancing troops. Given the

[241] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85.

[242] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85.

[243] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85.

[244] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85.

amount of optimism the artillerist had for the effectiveness of their week long preparatory fires, the rolling barrage was sequenced much too quickly. When the Germans emerged from their fortifications, which they did on July 1, the barrage that was supposed to be covering the advancing infantry had already been irrevocably shifted on its subsequent targets due to failed communication.[245] Also problematic, was that for all the precision the British showed in the laying of guns and synchronization with the other supporting arms, they failed to select the right composition of shells needed to truly impact the German fortifications. Of the 1,500,000 rounds launched during the week-long preparatory fire, roughly 1,000,000 were fired by the 18-pounders. Furthermore, they were shrapnel rounds, rather than the preferred and more effective bunker-busting high-explosive rounds.[246] The shrapnel rounds were supposed to slice the Germans' wire obstacles, but the real issue was one of production; British factories simply were not able to produce the quantity of high-explosive rounds needed for the war, and instead were just mass producing what they could—in this case shrapnel.[247] The remaining 500,000 shells were unequally distributed toward the smaller end among the various howitzers, which ranged from the 4.5-inch to the behemoth 15-inch.[248] The 15-incher's shell weighed 1,400 pounds but unfortunately there were only around 1,500 of these "super-sized" shells.[249] Furthermore, although accuracy had increased, artillery was still very much an area-effect weapon with a modest error of 25 yards.[250] However, against the intended targets of British artillery—German machine gun positions—of which many were inexactly known to begin with, an error of 25 yards would prove insurmountable. Later in 1917, General Plumer, an innovative British commander, would develop an artillery tactic that divided the German front into zones of fire so that the guns could

[245] Keegan, *The Face of Battle*, 252–253.

[246] Keegan, *The Face of Battle*, 238.

[247] Keegan, *The Face of Battle*, 238.

[248] Keegan, *The Face of Battle*, 234, 238.

[249] Keegan, *The Face of Battle*, 239.

[250] Keegan, *The Face of Battle*, 234–235.

saturate an entire area.[251] After the preliminary saturation, Plumer would have his troops advance behind a rolling barrage to seize the immediate German position.[252] Once in control of the immediate positions, however, the attack would cease rather than push deep and expose itself to a possible counterattack.[253]

This example shows some of the inherent difficulties in integration. The British army, for the most part, had adapted its organization and developed a rudimentary artillery-infantry combined arms doctrine by the Somme offensive. Certainly there were still areas of friction, specifically, in the communication between observer and battery and the synchronization of the rolling barrage with the march-rate of infantry soldiers. However, the real weakness of techno-strategic integration in this case was with industry. Failures of production in the type of shells needed could not be made up for with larger quantities of another type.

The Germans, having roughly similar technology, due in part to the diffusion of the arms industry prior to the onset of the war, had made the same integrating steps in the area of artillery science. The German defenses were laid out such that their secondary trench network was out of artillery range thus minimizing their adversary's artillery threat.[254] Furthermore, the Germans had established their defensive lines to take advantage of higher ground, also, their line was strengthened at regular intervals by what remained of the formerly built up villages in the area.[255] Where the urban maze of rubble did not exist, the German's "mined" their fortifications in some places as much as 30 feet underground.[256] But the masterpiece of the German defense was in their integration of machine guns. In many ways machine guns are similar to artillery. Foremost they are an area weapon; the "play" in a machine gun even when paired with a tripod due to the recoil it produces, creates a dispersed area where the rounds strike in what is known as a

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[251] G. J. Meyer, *A World Undone: The Story of the Great War, 1914–1918* (New York: Delacorte Press, 2006), 579.

[252] Meyer, *A World Undone: The Story of the Great War, 1914–1918,* 578.

[253] Meyer, *A World Undone: The Story of the Great War, 1914–1918*, 578–579.

[254] Keegan, *The Face of Battle*, 218.

[255]Keegan, *The Face of Battle,* 232.

[256] Keegan, *The Face of Battle*, 232.

"beaten zone." Machine guns, like artillery, were centralized and were capable, depending on the degree of elevation, of plunging fire which created a beaten zone as far out as 2000 yards.[257] Machine guns are also capable of, and more commonly used for, "grazing fire." In this use, the idea is to traverse the gun across a broad front at a fixed elevation so that the rounds are approximately one yard, or chest high, above the ground. Interlocking machine gun positions "ranged" onto wire obstacles designed to channel infantry into kill zones completed the defensive integration of machine guns, and was what awaited the British across no-mans-land; the small 18-pounder's shrapnel rounds were largely ineffective against the wire they were supposed to breach.

However, it is deceiving to say that the Germans were more techno-strategically integrated. At Verdun in late February 1916, the roles were generally reversed, the Germans employed an artillery preparatory barrage before an offensive thrust that gained little in the way of strategic objectives and were eventually ground down over the course of the next six months by the French who were primarily defending. In both cases, defensive concepts of operation were the more integrated techno-strategic approach. On the Somme, however, there appeared a new technology that fused armor with mobility and firepower. In an ironic juxtaposition of the old and the new, General Haig's three divisions of horse cavalry stood in fading glory while tanks entered the battle.[258]

Another solution to observation was increasingly being sought not from a forward observer, but from the air. Balloons had been used as a reconnaissance platform in the American Civil war, and now, with the addition of wired communication between the balloon and the ground it was only natural to employ them to assist gun batteries. In another of the First World War's peculiar juxtapositions, balloons rose gently into the air alongside the emergent revolutionary technology of airplanes. Of course, the main advantage of the airplane over the balloon was its mobility, but the airplane's ability to provide corrections was limited somewhat by the lack of a wireless radio capable of

[257] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85.

[258] Keegan, *The Face of Battle*, 246.

sending voice transmission—observations had to be sent by Morse code.[259] Besides balloons and airplanes, aerial combat in the First World War also saw the use of zeppelins. The zeppelin—basically combining the gaseous-based loft of a balloon but with a rigid metal frame—was able to carry a payload of bombs. Another advantage zeppelins had was their ability to fly above the altitude obtainable by the airplanes of the day; at least in the beginning of the war. Had the Germans integrated zeppelins into a larger reconnaissance role, on sea as well as on land, the advantages would have been significant. Instead the Germans would use zeppelins, in January 1915, to bomb cities in England and France—efforts that yielded no significant gain, but would later capture the imaginations of airpower enthusiast.

Combat in the air, and against air forces, became increasingly intense as the war progressed, thus, initiating a rapid cycle of evolutionary development and increasing techno-strategic integration. Innovation proceeded rapidly as a product of both deliberate design and trial and error. Prompted by a desire to limit enemy observation, it may have been inevitable that aviators would try to shoot each other down. Indeed, by early October 1914, aerial combat came of age when French Aviator Joseph Frantz shot-down his German counterpart.[260] However, true "dog-fighting" could not be realized until machine guns were built into airplanes by design. Work had begun on this problem in 1913, and by the spring 1915 Frenchman Raymond Saulnier had devised a solution whereby armored deflectors were incorporated into the propeller to shield it against errant bullet strikes.[261] Roland Garros, a pilot working with Saulnier utilized this solution successfully scoring three German kills before being forced down behind enemy lines.[262] Soon afterwards a more elegant solution was advanced by Germany. Pioneered by the Dutch engineer Anthony Fokker, the interrupter gear provided a mechanical solution that synchronized the rotation of the airplane's propeller with the trigger mechanism of the

[259] Keegan, *The First World War*, 359.

[260] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 71.

[261] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 74.

[262] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 74.

machine gun so that the gun could only fire when the propeller was clear.[263] The dawning age of fighter airplanes arrived in July 1915 with the release of the German Fokker E1.[264] Controlling the air became an increasingly crucial component of an effective strategy.

The Fokker E1, known in the press as the "Fokker Scourge," gave the Germans an initial advantage in the battle for air superiority. However, by the offensive at the Somme a year after the "Scourge's" inception, the initial German advantage had been overcome by allied development of the British DH2 and the French Nieuport.[265] Both the DH2 and the Nieuport were equipped with a forward-facing machine gun, and both were able to out-climb and out-turn the Fokker—essentially making the Fokker obsolete. Evolutionary pressures to build a better machine, thus, controlling the skies, would continue to shift the balance of air superiority, but while air superiority was becoming necessary it was not sufficient to ensure success.

Even with control of the sky, the allied effort at the Somme quickly devolved into the back and forth attrition so commonplace in the battles of the "Great War." By the end of July the Germans had lost 160,000 men and the combined losses of the French and British were over 200,000.[266] The pressure of necessity to innovate a technological solution that could enable a breakthrough had been mounting, and an officer in the Royal Engineers had hit upon a solution.[267] Colonel Ernest Swinton began circulating the idea in December 1914, but fundamentally, the tank sprang from a novel combination of existing technology.[268] Armored cars had been successful in the early stages of the race to the sea, but had quickly lost their mobility when fortifications were erected.[269] The

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[263] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 74.

[264] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 74.

[265] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 84–85.

[266] Keegan, *The First World War*, 297.

[267] Keegan, *The First World War*, 297.

[268] Keegan, *The First World War*, 297–298.

[269] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 265.

answer lay with tracked vehicles, which had been in use since 1899 for agricultural purposes and were now readily transformed to the business of planting men by the addition of plating and weapons.[270] Admiral Reginald Bacon had already designed a tracked artillery platform. As an example of the positive effect civil-military relations can have on the adoption of revolutionary technology, tanks—the name originated as an attempt to keep the project secret—were championed by Winston Churchill then first lord of the Admiralty.[271]

As Churchill's involvement suggest it was the Royal Navy that originally formed the "landship" committee. Given their relatively recent experience with armored ships this represented a natural, albeit odd, choice. Indeed, the same figures instrumental to dreadnought design and adoption, such as Lord John Fisher and battleship designer Eustace Tennyson-d'Eyncourt, were called upon to design and deliver an armored vehicle capable of making the all important breakthrough.[272] Industrialists too were called upon for their expertise. William Trinton, of William Foster's agricultural machinery company, teamed up with motor engineer Walter Wilson to design an improved track link which they coupled with a rhomboidal shape.[273] The fusion of political involvement, military necessity and input, and industrialist expertise produced three prototypes. The committee eventually settled on the Mark I design known affectionately as the "Mother;" it would become the basic design for all tanks in the First World War.[274] The Mark I went into production early in 1916, however, although a technology now existed that promised a return of mobility to the stagnant battlefields of 1916 there was no well thought out concept of employment—the process of techno-strategic integration had merely begun. As Robert O'Connell notes "the requisite device technology was more easily acquired than a suitable doctrine of employment."[275]

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[270] Keegan, *The First World War*, 298.

[271] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 265.

[272] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 265.

[273] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85–86.

[274] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 265.

[275] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 265.

Swinton, who's musing were largely responsible for the creation of the tank, suggested that the tank's effectiveness would be greater if they were kept off the battlefield until there were enough to affect a concentrated attack in conjunction with infantry.[276] However, in the hope that a few weapons alone would be enough, 32 tanks made their wartime debut on September 15, 1916 at the Somme. With so few a number, a large-scale strategic breakthrough was unlikely; however, where the tanks were employed an advance of 3,500 yards—nearly two miles—was achieved before the majority of the tanks mechanically failed and were subsequently destroyed by artillery.[277] With the debut made three processes started: evolution of the design, diffusion of the form, and integration into a concept of operation.

The British perhaps having learned from the relatively uninspiring effect of having too few tanks on the Somme brought 476 fourth generation Mark IV tanks to Cambrai in November 1917.[278] Also, and more importantly, the British brought an integrated concept of employment that capitalized on both surprise and combined arms coordination to achieve a four mile push through the heavily defended Hindenburg Line.[279] Unlike the Somme the decision was made to forgo a preparatory barrage at Cambrai to increase the likelihood of surprise.[280] Artillery, which had needed to register its guns to ensure accuracy, had been alleviated from this step by the innovations of artilleryman Brigadier General H. H. Tudor who was commanding the 9th Scottish Division during the Cambrai offensive.[281] Tudor, who along with Tank Corp commander Brigadier H. Elles had devised the operational plan for Cambrai, had developed a method where the guns could be electronically registered against the normal pattern of round distribution and then graphically depicted on a map eliminating the need

276 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 265.

277 Keegan, *The First World War*, 298.

278 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 91.

279 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 91.

280 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 91.

281 Keegan, *The First World War*, 369.

to fire a physical shell alerting the enemy to the possibility of attack.[282] Since surprise could also be foiled by enemy reconnaissance, the plan for Cambrai also included an extensive air component tasked to prevent enemy aerial observation of the pre-assault marshaling.[283] Furthermore, the artillery barrage was synchronized with the tank and infantry assault while the airplanes shifted from their pre-assault aerial denial role to a more aggressive bombing role directed toward German command and control positions.[284]

This was techno-strategic integration. It was also fleeting. Communications, still primarily by cable, inevitably broke-down preventing further offensive coordination as the initial assault objectives were obtained. The Germans, in many ways unable to capitalize on the advantages of imitation due to material shortages, had not been able manufacture tanks on any significant scale.[285] Although, by the end of the war, the Germans had managed to produce the A7V assault tank, which in the first instance of tank-on-tank battle engaged a Mark IV on 24 April 1918.[286] Diffusion of tanks also saw the development in France of the venerable Renault "light" tank. The Renault design included a rotating turret and was designed for mass production; the latter factor ensuring that when the Americans arrived they would be fighting in French tanks. In the counterattack at Cambrai on the 30th of November however, the Germans, lacking tanks, relied on a different type of techno-strategic integration. An integration that utilized infiltration techniques performed by small unit "shock troops" supported by lighter portable machine guns and artillery.[287] The German counterattack nullified the British gains at Cambrai, but it could not cancel the inevitable return of mobility to the battlefield.

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[282] Keegan, *The First World War*, 369.

[283] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 91.

[284] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 93.

[285] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 266.

[286] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 266.

[287] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 94–95.

The endgame was afoot when Russia succumbed to internal pressures resulting in the Bolshevik revolution in March 1917.[288] Germany freed of some of its commitments to the East was able to shift manpower and material to the West. By November 1917 this was occurring at a rate of 10 divisions a month.[289] Some of these "new" troops were specifically trained in infiltration tactics—the tactics employed in the counterattack at Cambrai. The United States declaration of war on April 6, 1917, however, would more than counter Germany's repositioning of forces. By March 1918 the American Expeditionary Force (AEF) numbered 318,000; by August the number had more than doubled twice to 1,300,000.[290] Furthermore, the Americans, having been spared from the preceding four years of fighting arrived at the front with an enthusiasm that had long since been beaten out of the other combatants.[291] Germany, although reaching the end of its ability to conscript new forces, and materially disadvantaged by 830 planes, 4,500 guns, and 790 tanks, was not ready to capitulate.[292]

The German spring offensive of March 1918 was prefaced on the techno-strategic integration of infantry infiltration tactics and artillery. It was a doctrinal solution to the failure of the frontal assault. Operation Michael was commenced on March 21, 1918, and was designed to pierce the British's Fifth Army who was holding the line on the old Somme battlefield.[293] The British line wavered and fell "the BEF had suffered its first true defeat since trench warfare had begun three and a half years earlier."[294] The worst was yet to come. Defeats continued to mount—by April 5th the Germans had pushed 20 miles across a 50 mile front, and were threatening Amiens[295] Germany's success however, prompted a revision of plan. Instead of continuing in a single thrust the modified plan directed forces along three separated avenues but the division of forces

288 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 267.

289 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 267.

290 Keegan, *The First World War*, 372.

291 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 268.

292 Keegan, *The First World War*, 392–393.

293 Keegan, *The First World War*, 394–395.

294 Keegan, *The First World War*, 400.

295 Keegan, *The First World War*, 402–403.

ensured that none were strong enough to meet their objectives.[296] The Germans mounted five offensives in the spring and summer of 1918 demonstrating the effective techno-strategic integration of infiltration and artillery.

The performance characteristics of aircraft also continued to rapidly evolve, and continued experimentation led to increasing techno-strategic integration. By 1916 aircraft performance and incendiary ammunition had thwarted the initial advantages of zeppelins.[297] Delivering bombs increasingly became the role of aircraft. In part this was a function of increased capability; better engines meant faster speed which translated into increased lift making aircraft, such as, the German 1917 Gotha IV bomber capable of carrying a 1300 pound payload.[298] Fighters had evolved as well, and by 1917 the British Sopwith Camel, French Spad XII, and German Fokker DVIII were nearly twice as capable as the planes available at the start of the war.[299]

On land, aircraft broadly performed four roles: 1: reconnaissance; 2: air-to-air combat; 3: air-to-ground combat (either by strafing or bombing); and, 4: bombing (here separated from air-to-ground to delineate the differences in attack against ground troops and attacks against city dwelling civilian populations). At sea the role of air-to-ground was morphed into air-to-ship by torpedo carrying seaplanes. As aircraft technology evolved specialization became increasingly necessary to maximize an aircraft's effectiveness within the role it was expected to perform. Techno-strategic integration occurred within each of the sub-forms but also as a whole. Holistically, the question is: How well did either side integrate aircraft across the broad spectrum of emerging forms into a cohesive concept of operations?

Reconnaissance, perhaps, presented the fewest challenges to integration—airplanes basically inherited the role from their aerial precursors. Integration of this form

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[296] Keegan, *The First World War*, 404.

[297] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 85.

[298] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 224.

[299] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 95.

was largely a matter of improving communications equipment, and photography. Air-to-air combat presented different challenges. Aircraft performance became in some ways the critical feature of air-to-air dominance in WWI with rapid shifts taking place over the course of months, and performance in general nearly doubling over the course of the war.[300] Innovation in this area was important but so was rapid imitation as noted by American ace Eddie Rickenbacker, "No Matter what innovation one side might develop, the other was quick to find out about it, copy it, and incorporate it in a new design."[301] Technological advances produced a better more capable aircraft, but integration was achieved by the development of aerial tactics. The iconic image of the individual "ace" testing himself and his machine against another equally capable foe is largely mythological—most aces, in fact, earned their reputations by gunning down novice pilots.[302] Aerial combat increasingly became a question of massing and synchronizing aircraft, which as a group in formation would hunt for their adversaries and then swoop in for the kill. Massing itself only became possible later in the war as industrialist applied mass production techniques to aircraft manufacturer—Germany alone produced 21,000 aircraft in 1918 in spite of growing resource constraints.[303] Alteration of the basic fighter form increased air-to-ground integration which also increasingly relied upon massed synchronization of aircraft working in conjunction with infantry and tanks.[304] The major split in form, however, occurred in the increasingly evolutionary development of bombers.

Bombers are effective based on their capability to carry a high payload of bombs over extended differences, as opposed to fighters which must be fast and maneuverable. Simply put, a good fighter cannot also be a good bomber and vice versa. Bombing against enemy troops and rear areas and against civilians in cities became increasingly

[300] Keegan, *The First World War*, 360Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 95.

[301] As quoted in: O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 262.

[302] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 263.

[303] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 98.

[304] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 98.

important as the war entered its final year. American colonel William Mitchell would mass 400 bombers carrying 79 tons of bombs against troop concentrations and munitions dumps in support of the Meuse-Argonne offensive in 1918.[305] Bombers targeting civilian residential and manufacturing centers also became both more prevalent, and also, more valuable. As the continuing trend of techno-strategic integration emphasized the mass production of material for use in a doctrine of mass synchronization it seems all but inevitable that the necessity of targeting production would arise as a central component of strategy. In this endeavor the bomber would eventually—and perhaps wrongly—be venerated above all other forms, but for now, in the final stages of the First World War, air-power for all its promise was not enough to break the stalemate.

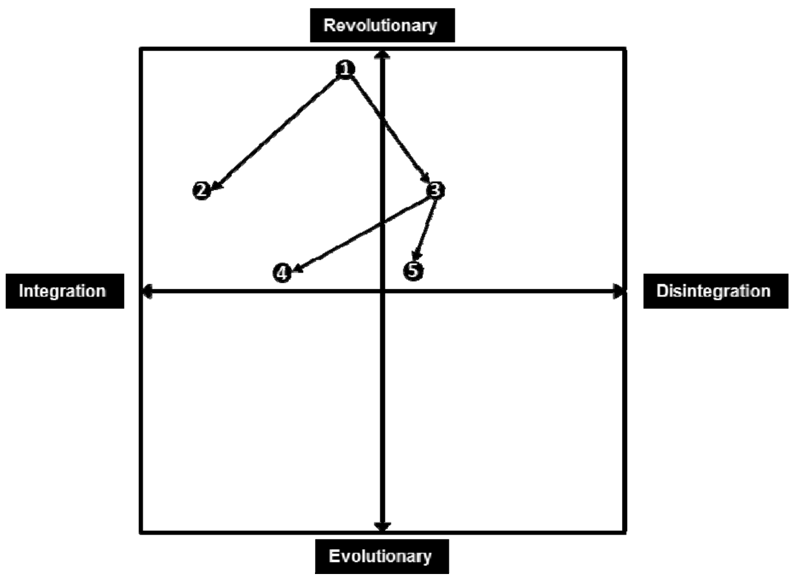

Figure 3. Figure showing the techno-strategic integration of aircraft during the First World War.

Although the evolution of airplanes was in many ways driven by the competition inherent in war, airplanes remained a revolutionary technology throughout the First World War. Point 1 represents airplanes at the start of the war where they were easily integrated into the role of reconnaissance. At point 2 continued advancements in photography and communication further integrated airplanes as reconnaissance

305 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 264.

platforms; also, airplanes increasingly became integrated as observation platforms for artillery. Early forays into air-to-air and air-to-ground combat were relatively disintegrated (point 3) with most engagements performed by individuals against targets of opportunity. Evolutionary pressure to produce a better airplane led to rapid advancements in aeronautical engineering. Engineering advances created the ability for specialization and the form to diverged resulting in both fighter and bomber archetypes. Fighters (point 4) became increasingly techno-strategically integrated with an overall concept of operations that stressed mass synchronization. Manufacturing capabilities increased to include mass production of aircraft, which were now working in groups to find, fix, and finish their opponents, and were also performing the additional task of bombing and strafing enemy field units. Pure bombers (point 5), such as, the German Goth IV while showing increasingly evolutionary design were disintegrated. Bombers were rarely able to find and hit their targets, and were easily thwarted by both the more nimble fighter aircraft, and anti-aircraft gunnery.

In addition to integration of both sides in the air the allies had also integrated on land. The allies successfully countered German infiltration advances with their own application of combined arms tactics, which, unlike the Germans, included tanks. As the fighting continued it became clear that the allies, possessing the ability to replace their casualties with the untapped manpower of America, and possessing a material and manufacturing advantage had the upper hand. At Amiens on the 8 August 1918, using tactics reminiscent of Cambrai, the allies employed 604 tanks fracturing the German line in both depth and breadth.[306] It was the beginning of the end. Subsequent victories mounted for the allies whose force was strengthened daily with the arrival of fresh American units. On 26 September 1918 the allies attacked with 123 divisions, another 57 were held in reserve, against 197 German divisions of which only 51 were considered full strength.[307] Half-hearted fighting occurred right up to the end 46 days later, but the fight

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[306] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 99.

[307] Keegan, *The First World War*, 412.

was really over. The political situation in Germany was also deteriorating. Socialism was on the rise and the monarchy was in decline, and days before the armistice Wilhelm II relinquished the emperorship.[308]

There is little doubt that the Germans would have built more tanks, more airplanes, and thrown more men into the war if they had the capability. They had successfully reconciled their pre-war disintegration between a doctrine of offense and the technology of the day; however, in the end this example shows that integration of doctrine and technology without an underlying industry that is capable of meeting the need of its military is also an important factor in techno-strategic integration. The allies were also, able to reconcile their pre-war disintegration, but in their case industry was able to produce, and specifically, to produce tanks. Furthermore, the late entry of America ensured that the machines of war would be manned.

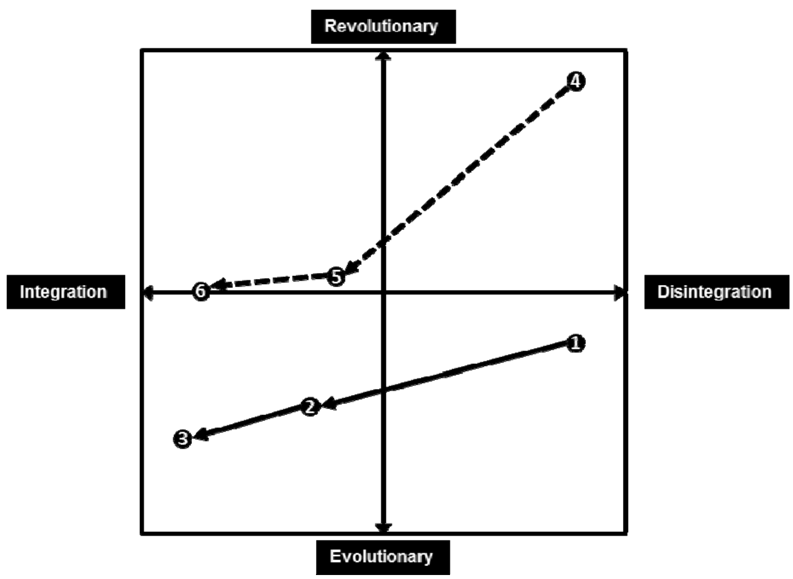

Figure 4. Figure showing allied and German (solid), allied (dashed) techno-strategic integration on the Western front during WWI.

Point 1 represents Germany and the allies at the start of the war and reflects the disintegration between the evolutionary technologies of rail, artillery, and machine guns and an offensive concept of operations. Point 2 reflects German and allied movement

[308] Keegan, *The First World War*, 414.

toward the integration of artillery and infantry in an offensive concept of operations through the development of artillery tactics such as the rolling barrage, and the inclusion of meteorological data to enhance accuracy through registration. Later integration included the development of firing accurately "unregistered," which was accomplished through the study of round deviations conjoined with mathematical modeling and maps. In point 3, Germany took a further step toward integration of artillery and infantry by developing infiltration tactics, which employed a light machine gun combined with close coordination of artillery and the employment of smaller dispersed units of shock troops. In point 4, allied forces, employing the technologically revolutionary tank exhibited early disintegration such as at the Somme in Sept 1916. By point 5 however, further evolution of the form and increasing integration in a comprehensive concept of operations that employed infantry and artillery in conjunction with tanks and airplanes was evident by Cambrai in Nov 1917. At Amiens in August, 1918 continued evolution and integration had occurred and was evident in what, according to Ludendorff, was the "black day of the German Army."[309]

1. Irregular Integration: Camels, Dynamite, and Sabotage

In the Middle East and Africa a completely different type of techno-strategic integration was occurring; one that in some ways shows an inverse relationship to what was occurring on the western front. The Middle East and Africa were an economy of force efforts; a constraint that may have fostered the unique approach to techno-strategic integration seen in those theaters. While on the western front integration primarily consisted in designing techniques to use tools, such as airplanes, tanks, and artillery in the most efficient way, integration in both the Middle East and Africa shows how the tools themselves present vulnerabilities which can be exploited. The latter integration, of course, also relies on man's application of technology toward a specific end, but in this case the method involves subterfuge, dispersion, and sabotage over massed manpower and manufacturer.

[309] As quoted in: Keegan, *The First World War*, 412.

The German campaigns in their relatively recent and discontinuous colonial holdings in Africa—Togo, Cameroon, Southwest Africa, and East Africa—were for the most part uninspired with the exception of East Africa. In East Africa Colonel Paul von Lettow-Vorbeck would lead a guerilla campaign to the very end of the war in 1918. Lettow-Vorbeck, with his relatively small force the, *Schutztruppe* numbering 2,500 askaris and 250 white officers, was able to repeatedly antagonize and attrite superior British forces.[310] Lettow-Vorbeck's attrition strategy however, in contrast to the Western Front, did not rely solely on throwing soldiers at the enemy and hoping to come out ahead. Instead of futility meeting his enemy head on, Lettow-Vorbeck employed a strategy emphasizing mobility and dispersion, which not only resulted in a disproportionate allied casualty rate, but also created attrition by drawing increasing numbers of British soldiers and material away from the main theater of the war. Part of what made Lettow-Vorbeck so successful was his techno-strategic integration of the machine gun.

Instead of massing machine guns into centralized companies, and positioning them to maximize the mass effect of their fires, Lettow-Vorbeck recognized the value of dispersing his guns into individual positions held by small teams.[311] Dispersed gun teams could simply control more terrain, furthermore, when threatened these guns teams would ideally hold until other *Schutztruppe* arrived to reinforce them.[312] When reinforcement was impossible the gun teams would displace before being overrun fighting a mobile defense in contrast to the static defense on the western front. Lettow-Vorbeck used these tactics effectively to staunch an early British invasion at Tanga in November 1914 against odds that were nearly eight-to-one. The British forces retreated in such haste that the *Schutztruppe* captured 16 machine guns and 600,000 round of

[310] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 146.

[311] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 148.

[312] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 148.

ammunition.[313] Lettow-Vorbeck was also able to repel another invasion this time at the port of Dar es Salaam causing the British to abandon landings in favor of an overland invasion from their colony to the north.

Undeterred, Lettow-Vorbeck continued his campaign of mobility, dispersion, and timely reinforcement defeating the British at Jasin. Supplied with captured equipment, Lettow-Vorbeck extended his concept of dispersion to a limited offensive campaign throughout 1915 aimed at the sabotaging the British East African rail line.[314] In this instance Lettow-Vorbeck was essentially targeting the techno-strategic integration of his adversary, whose dependence on the rail stands in sharp contrast to the *Schutztruppe* who could resupply off the land and from captured enemy depots. Indeed, one of the most important lessons the study of Lettow-Vorbeck teaches is that techno-strategic integration can work both ways—for every advantage there may be a corresponding vulnerability.[315] Dispersion of Lettow-Vorbeck's forces throughout the countryside, and their nearly constant attacks on the railroad, also, gave the appearance of a much larger force causing the British to allocate more men and material against them in a type of attrition by misperception.[316]

By 1916 the British had had enough. The British reinforcements under the command of Jan Smuts were able to reposition forces within Africa due to the poor showing of German colonials in German Southwest Africa, and the conclusion of a limited Boer rebellion that had occurred at the start of the war in 1914. Lettow-Vorbeck held firm to his techno-strategic integration of machine guns, dispersion, and mobility; fighting a prolonged retrograde southward that paired *Schutztruppe* hit-and-run tactics against massed numerically superior forces. However, unlike the British who seemed to only know one tactic—the frontal assault—Lettow-Vorbeck forces were also capable of

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[313] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 148–149; Keegan, *The First World War*, 211.

[314] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 150.

[315] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 168.

[316] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 150–151.

holding their ground when the situation called for it, as it did in October 1917.[317] By this date Smuts had returned to Britain and had been replaced by Major General Jacobus van Deventer, who, seeking to destroy Lettow-Vorbeck's forces attacked *en masse* along the Mahiwa River.[318] As on the Western Front the technology favored the defender; Lettow-Vorbeck's 1,500 held against van Deventer's 6,000; although, both sides took proportional casualties.[319] Lettow-Vorbeck, as before, did not limit his activities to the defense. Rather in 1917, and generally through the remainder of the war, he conducted a primarily offensive campaign that favored raiding.

Lettow-Vorbeck's employment of technology never exhibited the disintegrated character that defined operations on the Western Front in the early offensive push of 1914. Rather, from the start Lettow-Vorbeck concept of techno-strategic integration accounted for the inherent defensive nature of a well emplaced machine gun. Using mobility and dispersion Lettow-Vorbeck was able to extend the power of his machine guns into a larger area of operation, and repeatedly attrite British offensive attacks. Partly this was enabled through Lettow-Vorbeck's inferior numbers, which prevented him from meeting the British head on. Lettow-Vorbeck, brilliantly, attacked where the enemy was weak along the miles of undefended railroad track that the British needed logistically, which stands in contrast to the *Schutztruppe's* ability to live off the land and from what he could capture. Interestingly, German infiltration tactics toward the end of the war in some ways made the same use of mobile dispersed units armed with machine guns against weaker targets, but, in Lettow-Vorbeck's case, the similar solution was arrived at without the carnage. Perhaps his paucity of troops inspired Lettow-Vorbeck's concept of operations leaving us to question whether the availability of manpower in itself was the cause for its apparent disregard in Europe.

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[317] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 153.

[318] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 152–153.

[319] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 153.

Roughly during the same time, but in the Middle East, T.E. Lawrence, another undermanned raider, was using a similar concept of operations using Arab fighters against the Turks proving that this type of techno-strategic integration was not confined to Africa.[320] Lawrence's case however, offers a subtle difference. While Lettow-Vorbeck was using his *Schutztruppe* against a conventional force, Lawrence was using his Arab fighters in conjunction with a conventional force. Indeed, the allied conventional effort against the conventional Turkish Army—strongly buttressed by a German advisory effort—engaged each other in one of the most famous battles of the war: Gallipoli.[321] However, rather than diverting German men and materials away from the war in the western front the allied defeat at Gallipoli (January 1916), and soon thereafter at Kut (April 1916) reversed the situation and was now costing the allies more than it was hurting the enemy.[322] Lawrence, arriving after Kut in 1916, offered a new approach to British operations in the Middle East.

Echoing Lettow-Vorbeck, Lawrence pitted his efforts against the Turkish reliance on the rail line, again demonstrating a relationship between capability and vulnerability.[323] Furthermore, Lawrence's concept of allying with the disenfranchised Arab freedom fighters under the leadership of Sherif Husein reduced the British manpower investment, thus magnifying the impact of his operations. Lettow-Vorbeck techno-strategic integration focused, primarily, around machine gun technology combined with an operational concept of mobility, and dispersion. Lawrence also, recognized the need for mobility and dispersion, but his favored technology was dynamite.[324] However, Lawrence did not limit his action merely to sabotage; he was able to orchestrate cooperation between his dispersed forces when needed against larger

[320] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 159.

[321] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 159.

[322] Keegan, *The First World War*, 301.

[323] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 159.

[324] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 160.

targets which he did successfully at Aquba in July 1917.[325] Moreover Aquba, which was held by 1200 Turks cost Lawrence two men—a startling contrast to the attritional battles of the Western Front and evidence that an offensive concept of dispersion may carry with it an increased likelihood of surprise.[326] As the campaign in the Middle East continued, Lawrence found himself extending his concept of irregular operations in concert with General Edmund Allenby's more conventional operations. Following Allenby's capture of Jerusalem toward the end of 1917, pressures on the Western Front, from Germany's renewed 1918 offensive, forced the British high-command to reallocate some of Allenby's forces.[327] Allenby, however, would not be content to sit in Jerusalem. Instead, working with Lawrence, an offensive campaign for 1918 was devised that made effective use of Lawrence's Arabs, and Allenby's mass. Lawrence would in essence create a feint inland using his dispersed forces in a series of attacks designed to give the appearance of the advance guard of the main attack.[328] Meanwhile, Allenby would concentrate the main body of his forces against the Turks along the coastline en route to Damascus. When Damascus fell in October 1918 at the cost of 450 men it was a clear victory, as opposed to the pyrrhic victories of the Western front. It was also a clear demonstration of the power of technology. Machine guns and dynamite concentrate destructive power, and, in both the case of Lettow-Vorbeck and T.E. Lawrence, this concentration was used to extend the capabilities of the small groups by dispersing forces rather than massing them—a concept of techno-strategic integration that yielded both surprise and protection.

D. NAVAL IMPOTENCY AND INNOVATION: BLOCKADES, BATTLESHIPS, AND COMMERCE RAIDING.

The allied advantages of men and materials at sea were in some ways predicated by the techno-strategic disintegration inherent in Germany's pre-war adherence to

[325] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 160.

[326] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 160.

[327] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 165.

[328] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 166–167.

Mahan's concept of naval operations, which favored decisive combat between fleets over commerce raiding. Naval technology such as submarines was changing the paradigm, control of the sea was no longer a two dimensional enterprise. However, it is arguable that the German Admiralty recognized this in their initial, and later resumed pursuit of unrestricted submarine warfare. But, the grip of naval traditionalist in the pre-war naval arms race and international condemnation during the war prevented Germany from committing to a submarine based fleet of, at that time, undetectable commerce raiders, and had rather predisposed them to a position of numerical inferiority in battleships.

Naval competition and it effect on ship development leading into the war, (discussed in the last chapter), had in rapid order transformed the Royal Navy's fleet. In a series of evolutionary advancements—advancements aimed at improving existing characteristics—ships went from mounting four 12-inch guns at 13,000 tons capable of 18 knots powered by a coal burning piston engine in 1896 through the *Dreadnought* design in 1906 to a design mounting eight 15-inch guns at 26,000 tons capable of 25 knots by an oil burning turbine engine in 1913.[329] Keegan also notes that this rapid change is all the more remarkable because each evolution in ship design had the corresponding impact of making the entire previous generation obsolete—a clear indication of the monetary investment Britain was willing to make in the "maintenance of maritime predominance."[330] Technological diffusion, a product of the privatization of arms manufacturing which resulted in foreign sales and industrial collusion between private firms, ensured that any short-term evolutionary gain was rapidly imitated by strategic competitors. The international bonds of the arms industry were, indeed, so tight that some of cooperation between British and German manufacturers continued into the early years of the First World War.[331]

The similarities in ship design can be explained, in part, by the environmental pressures both Germany and Britain faced. Both countries had accepted a Mahanian view of naval operations, which stipulated a doctrine of naval dominance and correlated

[329] Keegan, *The First World War*, 258.

[330] Keegan, *The First World War*, 259.

[331] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000,* 292.

to standing "traditionalist" views of naval power. Also, the privatization of the naval armament industry, which was highly specialized and entails significant investment cost, increased foreign sales as private firms sought to recoup expenses. Foreign sales increased the exposure of the technology, leading to widespread diffusion. Finally, diffusion undercut any strategic advantage generated by the current technological suite, thus, increasing the demand for next generation technology. Hence the rapid evolutionary cycle of ship design between England, Germany, and others. However, for all the similarity between British and German navies there were also some important differences. German ships had better shells, better armor, and better optical gun sights. German shells, unlike their English counterparts, were capable of penetrating armor on a glancing blow.[332] However, having better ships does not mean that the Germans had made the right techno-strategic decision. Tirpitz's decision to forego investing in submarines shows a lack of consideration for the new in favor of the old. German ships were good ship they were more heavily armored and had a more survivable compartmentalized magazine design.[333] Finally, German ships had better range finding equipment.[334] The latter in some ways being the most egregious of the three because the British admiralty made the decision to forgo A.J. H. Pollen's better, privately developed, range finder in favor of an "in-house" design was made to avoid having to pay Pollen the sum of £100,000.[335] However, besides the saving the £100,000—a truly inconsequential sum when compared against the 32.3 million pound budget of 1909—Pollen's device was deemed unnecessary because it yielded the capability of firing while the ship was performing maneuvers.[336]

[332] See footnote in McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 294–295.

[333] Keegan, *The First World War*, 259.

[334] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 281.

[335] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 295.

[336] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 287, 295–297.

The competing device, which could not account for lateral movement, conformed to the traditionalist conception of line-ahead tactics.[337] The failure to adopt the Pollen design is indicative of a lack of coherency in Royal Naval Doctrine. Nelsonian line-ahead tactics which made the Pollen sight unnecessary rested on a conceptualization of naval encounters as a race to close the distance with and decisively defeat the enemy fleet.[338] However, the Nelsonian concept of operations was already being impugned by other technological decisions being made in the Royal Navy. British ships had and maintained a gun-size, and therefore, a range advantage over the Germans. Thus between 1905–1910, in an effort to make the most of the range advantage inherent in their larger guns the Royal Navy under the leadership of Admiral Fisher designed a new class of ships—the battle cruiser.[339] Traditionally, cruisers were tasked to screen in front of the main armada capitalizing on their speed to alert the fleet while avoiding danger. Battle cruisers, however, were conceptualized not only to screen but also to fix and possibly destroy the enemy's fleet through engagement while the main fleet moved to join battle. To accomplish this task the battle cruiser had the same guns and size of its cousin the battleship, but was lightly armored to increase its speed. The entire concept of the battle cruiser was built on its combination of superior speed and range. It was designed to chase down its more heavily armored opponents and destroy them with its larger guns while remaining out of range of it adversary. However, the Admiralty by eschewing the Pollen sight had made a technological decision that essentially prevented battle cruisers from being able to engage targets at the far end of its range, thus, exposing the lightly clad battle cruiser to the enemy's fire. The disintegration in Royal Navy techno-strategy was indirectly acknowledged in its regulatory guidelines which specified a range 9000 yards for target practice—a distance of less than half of a battle cruiser's max range and

[337] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 296.

[338] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 296.

[339] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 297.

well within the enemy's.[340] British battle cruisers would, more than any other ship design, pay a heavy price for their techno-strategic disintegration at Jutland (31 May–01 June 1916).

Battle ships and their attendant fleet of battle cruisers, torpedo boats, and destroyers represented, in theory, the techno-strategic integration of early twentieth century naval engineering and Mahan's naval doctrine of decisive battle between massed fleets. However, the conditions of this union between technology and strategy were rapidly dissipating. The troublesome technology of torpedoes was integrated into the massed fleet concept by designing a class of swift maneuverable ships to carry the weapon system against its primary target the battle ship. The menace of torpedo boats necessitated a counter, thus the torpedo boat destroyer joins the fleet. So far so good, the Mahanian paradigm is maintained with some minor adjustments to the composition of the fleet. Undersea mining and submarines, however, proved more difficult to assimilate and both by the end of WWI would demonstrably impact naval operations.

In contrast to the expectations of Mahan's disciples in both the Britain and Germany, naval operations in the First World War were defined more for their absence than for their decisiveness. Evidence of the growing dissociation between naval reality and naval theory was evident in the Mediterranean during one of the first encounters of the war. German Admiral Souchon commanding a "fleet" of two ships ran into British Admiral Troubridge commanding four armored cruisers as the former was headed to Constantinople. Although Troubridge enjoyed a two-to-one advantage over Souchon, decisive battle was not sought. Troubridge broke off after some minor action because in accordance to WWI naval logic his force mounting twenty-two 9.2-inch guns was "outnumbered" by Souchon's ten 11-inch guns.[341] Troubridge's actions would be called into question and he did face a court-martialed.[342] However, Troubridge's hesitation was indicative, to some degree, of a larger fear shared throughout the navy of losing ships. Granted no navy wants to lose a ship, but the balance between calculated risk and risk

[340] McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 298.

[341] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 247.

[342] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 247.

aversion can sometimes separate victory from defeat. Winston Churchill commented that commander of the Grand Fleet John Rushworth Jellicoe was “the one man who could have lost the war in an afternoon.”[343] Martin van Creveld commenting on the lack of audacity in the employment of battleships, notes that “[t]o be in use in war, however, a weapon *must* be expendable.”[344]

Underwriting the lack of audacity on the English side was their adherence to an increasingly evolutionary disintegrated concept of naval operations. The admiralty had done everything right to fight within an outmoded paradigm, their ships were more numerous[345] and more heavily gunned; in any straight forward meeting of fleets England had the advantage. However, British perception was incongruent with reality—control of the sea was no longer confined to the surface. Germany’s movement of the High Seas Fleet to the Baltic and out of harm’s way after losing four out of five ships in naval action off the coast of the Falkland Islands in December 1914 showed a similar lack of audacity, at least in its surface fleet.[346] Tirpitz had pushed the development of German sea power during the pre-war years as a challenge British hegemony.[347] The High Seas Fleet was built based on Tirpitz’s “risk theory,” as a deterrent that fixed the ratio of naval strength of Germany to Britain.[348] Germany would have fewer ships than Britain, but would locally achieve superiority by concentrating the High Seas Fleet in the North Sea.[349] When the First World War broke out Germany was, by design, inferior in number, and was now facing the entire British fleet not merely the portion allocated to duty in the North Sea. Germany, perhaps recognizing that their numeric disadvantages excluded them from a decisive victory in the Mahanian tradition, sought a concept of operations

[343] As quoted in O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 248.

[344] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 207.

[345] Britain and her allies had a decisive edge of 15 dreadnoughts, five battle cruisers, nine pre-dreadnoughts, 242 destroyers and torpedo boats, and 135 submarines according to Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 59.

[346] Montgomery, *A History of Warfare*, 480.

[347] Jonathan Steinberg, *Tirpitz and the Birth of the German Battle Fleet: Yesterday's Deterrent* [Yesterday's deterrent], 1 reprint ed. (London: Macdonald & Co., 1965), 18.

[348] Steinberg, *Tirpitz and the Birth of the German Battle Fleet: Yesterday's Deterrent*, 18–19.

[349] Steinberg, *Tirpitz and the Birth of the German Battle Fleet: Yesterday's Deterrent*, 21.

that could take advantage of the more revolutionary technology of submarines. However by the time the advantages of submarines were realized it was already too late. If the integration had occurred before the war the consequences may have been great.

While early encounters between surface fleets were largely indecisive in 1914—as they would be later at Jutland—submarines were proving their mettle. In one early encounter (September 1914) the German submarine U-9 sank three armored cruisers within an hour.[350] The Royal Navy, recognizing the dangers of undersea mines and short-range submarines to a close blockade, established its blockade force at a distance in the Scapa Flow off the Orkney Islands where it could intercept merchant shipping.[351] Although submarines never penetrated the Scapa Flow it was not because of a lack of range.[352] The growing presence of submarines and mines in the North Sea only served to increase the precautionary mindset of Jellicoe who, after losing the *HMS Audacious* on 27 October 1914, wrote to the Admiralty of his fears of being baited into a mine / submarine ambush.[353] Jellicoe's apparent solution—to not give chase—foreshadowed Germany's minimal contested retreat at Jutland.[354] However, the general fear of submarines infiltrating the Scapa Flow never materialized. By the end of 1914 Germany was already questioning the wisdom of risking its submarine force against battleships when it could be used instead to attack commercial vessels. By February 1915 the decision was made. Germany declared the areas surrounding Great Britain and Ireland a war zone and advertised that ships in these waters could be sunk at will—Germany commenced unrestricted submarine warfare.[355] This decision, for as long as it was practiced, became an element of Germany's grand strategy in the First World War, as

[350] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 249.

[351] Montgomery, *A History of Warfare*, 480.

[352] Montgomery, *A History of Warfare*, 481; O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 249.

[353] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 250.

[354] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 250.

[355] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 250.

such, it was not solely a military matter. Rather it represented a civil-military agreement. At first Chancellor Bethmann-Hollweg resisted the idea he eventually agreed and within months of the decision 39 commerce ships had been lost to submarines.[356]

Although, in essence all this amounted to was a reformulation of the age-old method of commerce raiding, the German willingness to attack commerce ships without warning seemed especially reprehensible given the inherent surreptitiousness of submarines. However in commerce raiding the relatively revolutionary technology of the submarine may have found its techno-strategic niche in the First World War. The losses escalated, reaching 135,000 tons monthly by the summer of 1915.[357] Importantly, though, submarines were not able to interdict every merchant ship, and many ships continued to get through, in contrast to the "distant" blockade imposed by Britain which eliminated Germany's access to seaborne supplies.[358] The Royal Navy, lacking effective counter-measures, and unwilling to detach its destroyer fleet to safeguard merchant vessels, did not have a viable solution to defeat this revolutionary-integrated form of warfare. However, the foundations of Germany's grand strategy of unrestricted submarine warfare were already sinking. On 7 May 1915 the German submarine U-20 sank the *Lusitania*, and on 19 August U-24 sank the *Arabic*. American President Woodrow Wilson was particularly incensed and the British, having no other counters, joined him in renouncing Germany's tactics. The moral indignation of the strong, facing an asymmetric threat that showed their underlying weakness to the techno-strategic integration of submarines and commerce raiding, found their voice in diplomatic castigation. Germany ceased its submarine campaign against commercial shipping in September 1915 only to resume it in February 1917. In a variation of diffusion whereby the style of integration is not directly imitated but is instead countered, the exposure to unrestricted submarine warfare and the short reprieve enabled the development of countermeasures—technological as well as tactical. In the meantime however, the

[356] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 250–251.

[357] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 251.

[358] Keegan, *The First World War*, 265.

techno-strategic fusion of big gun battleships and a traditional Mahanian naval concept of operations would occur at Jutland; and, in its inconclusiveness, Jutland would shed light on the disintegration of this union.

In some ways the abandonment of unrestricted submarine warfare made Jutland possible. With the astronomical casualty rates pouring in from the fronts the German navy must have felt compelled to act. Indeed, Bethmann-Hollweg and the German government were increasingly facing pressure to resume Germany's crusade on commerce as early as February 1916.[359] Unwilling to face the diplomatic torpedoes of international condemnation but nevertheless needing to take action, Bethmann-Hollweg placed the High Seas Fleet in the command of Vice Admiral Reinhard Scheer—an officer that had long championed using the surface fleet in a more offensive role.[360] Scheer started using elements of his fleet in a series of hit-and-run raids, but the range and duration of his attacks were limited by the looming presence of the Vice Admiral David Beatty's battle cruiser fleet, which had been positioned at Rosyth.[361] Scheer, unknowingly echoing Jellicoe's fears, constructed an operational plan to use a contingent of battle cruisers under Franz Hipper to lure the British battle cruiser fleet into a submarine ambush.[362] The Germans' gambit included a deception plan to misdirect the British by leaving a ship in port sending transmission as though it were Scheer's flagship giving the appearance that Scheer's fleet was still in port.[363] The British were partially deceived; Jellicoe, believing that the German fleet was still in port slowed his advance to conserve fuel.[364] However, if Scheer had known that Jellicoe and the battleships he commanded were moving it is likely that the battle would have never occurred. Scheer's plan was orchestrated to achieve superiority by drawing out Beatty's battle cruiser fleet and pitting against the entire German fleet. England in possession the German code book

359 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 256.

360 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 256.

361 Keegan, *The First World War*, 268–269.

362 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 257.

363 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 79.

364 Keegan, *The First World War*, 269.

was able to deduce Scheer's intention to resume the offense as he had done throughout April and May, therefore, Jellicoe had preemptively sailed to a position where Scheer could be interdicted in effect setting his own trap.[365] Socially sanctioned traditionalist approved naval battle would commence on May 31, 1916. Like a heavyweight boxing match that goes to decision the battle between these opposing fleets would leave the audience unsatisfied.

First contact occurred after Beatty's battle cruisers passed through the submarine ambush undetected.[366] Both Beatty and Hipper played their part after elements of their fleets identified each other while conducting reconnaissance of the same merchant vessel. Hipper withdrew towards Scheer's superior force, and Beatty gave chase. The British battle cruisers, which had been designed for speed, closed the distance.[367] However, the evolutionary-disintegrated British battle cruisers were speeding to their own demise. They had been designed to employ their speed and big guns to range the enemy while remaining outside of the enemy's range, which, but their speed came at the cost of armor. However, lacking an adequate optical range finder, the battle cruiser's ability to hit targets at the max range of their guns was purely theoretical. Closing to within effective range exposed the swift but lightly armored battle cruisers to the enemy's fire; and, the Germans, having the technological advantage of Zeiss optics fired the opening salvos at Jutland.[368] The British battle cruiser fleet's techno-strategic disadvantages were tragically becoming apparent. The *Lion*, *Indefatigable*, and *Queen Mary* were all hit within 20 minutes wounding the *Lion* and sinking both the *Indefatigable,* and *Queen Mary*—a third battle cruiser, ironically named, *Invincible* would be lost be the end of the day.[369] The weakness of the battle cruiser's poorly protected magazines made them especially vulnerable to German shells, which unlike their British counterparts penetrated

[365] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression,* 257.

[366] Keegan, *The First World War*, 272.

[367] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle,* 79.

[368] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle,* 79.

[369] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle,* 79.

before detonation.[370] The rapid loss of two ships and the near catastrophic hit on his flag ship the *Lion* caused Beatty to comment to his flag captain that "[t]here seems to be something wrong with our ships today"—and there was, they were techno-strategically disintegrated from naval reality.[371] The battle had merely begun.

Beatty, in pursuit of Hipper, recognized his vulnerability upon contact with some of the additional elements of Scheer's fleet and turned course toward Jellicoe. The tide of battle was now ebbing in the British favor. Scheer's fleet found its T crossed, and unable to match the range of the British's 15-inch guns, was subjected to a withering barrage.[372] Scheer, fortunately for his sailors, had thought through the implication of having his T crossed, and disseminated the order to execute a turning maneuver that allowed them to quickly exit the engagement area.[373] Scheer, perhaps feeling the weight of the navy's unequal contribution in blood, was not ready to capitulate. A second clash of battle ships commenced as Scheer attempted to maneuver his ships around the British. Jellicoe, however, had received reports from his cruisers of the German course, and once again was able to position himself across the German T.[374]

The German fleet was illuminated by the setting sun allowing the British gunners to exact 10 minutes of horror as they struck the enemy fleet 27 times while only suffering two hits.[375] Had Germany recognized the value of a zeppelin based reconnaissance effort in support of naval operations Scheer may have been able to out maneuver Jellicoe. Instead, lacking information, Scheer ordered the second turnabout of the day, only this time it was also followed with instructions to his battle cruisers and torpedo boats to charge the enemy in a "death ride" action to cover the retreat of the main battle fleet.[376]

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[370] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 79.

[371] As quoted by O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 257.

[372] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 79.

[373] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 258.

[374] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 82.

[375] Keegan, *The First World War*, 273.

[376] Keegan, *The First World War*, 273.

As the German battle cruisers turned toward the British with the intention to ram, they also fired a salvo of 31 torpedoes.[377] Jellicoe on the precipice of history was true to his word; he turned away from the enemy's underwater onslaught—Jutland would not be a second Trafalgar. As night settled in, the German fleet would complete their disengagement at the price of three ships.[378] The literal "death ride" of the battle cruiser in some ways morphed into the metaphorical death of the techno-strategic integration of battle ship fleets and Mahanian notions of control of the sea. The High Seas Fleet and the Grand Fleet would not meet again in the First World War.[379]

	British	German
Battleships	0	1
Battle Cruisers	3	1
Armored Cruiser	3	0
Light Cruisers	0	4
Destroyers	8	5
Sailors	6748	3058

Table 1. British and German losses at Jutland 1916 (From[380])

Inconclusive results yielded controversy, both sides claimed victory. The British lost more ships and more men; however, it was the Germans who had fled. Strategically, Britain remained in "control" of the sea. However, Germany may have won in the sense that even though they considered the battle a victory there may have also been a realization that they had escaped annihilation. Scheer, who had once championed surface combat, thus, recommended the *resumption* of unrestricted submarine warfare following Jutland. The "conversion" of Scheer, a surface navy traditionalist, greatly facilitated Germany's acceptance of techno-strategic union between submarines and commerce raiding, but it was a conversion too late to be decisive. Although there were some minor

377 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 258.

378 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 83.

379 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 259.

380 Raw data provided in Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 83.

surface engagements following Jutland, the bulk of the German surface navy languished in the North Sea and by the end of the war the High Seas Fleet would mutiny rather than fight.[381]

Unrestricted submarine warfare was resumed in February 1917. In April German submarines would sink 900,000 tons.[382] The tactical solution of merchant convoys was unsavory to Jellicoe who was unwilling to detach his destroyers for their protection.[383] Nevertheless, vice admiral William Sims commander of U.S. naval forces in Europe and an early dreadnought proponent saw things more clearly—command of the surface seas was hollow if it did not amount to maintaining sea lines of communication. Sims recognized the techno-strategic imbalance between Jellicoe, who was holding onto the old paradigm and potentially losing the men and materials needed to win the war, and Germany who had made the paradigm shift and were capitalizing on the techno-strategic integration of submarines and commerce raiding. The U.S. Navy Department thought arming merchant vessels was the best solution to the submarine problem, but Sims argued arming merchant vessels would just prompt submarines to use torpedoes.[384] Sims took action, recommending to both the British Prime Minister Lloyd George and the American President Woodrow Wilson that America revise its naval plan to include detaching the U.S. destroyer fleet for convoy escort and also to redirect construction away from battleships into additional destroyers.[385] With a senior naval officer making the recommendations, the politicians felt more comfortable effecting the changes that they had already perceived as necessary. Civil-military relationships built on the interchange of ideas and recommendations by military and civilian officials willing to look at problems without the moorings of traditionalist preconceptions once again appear effective at influencing change.

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[381] Montgomery, *A History of Warfare*, 481.

[382] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 259.

[383] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 259.

[384] Paul G. Halpern, *A Naval History of World War I* (Annapolis, Md.: Naval Institute Press, 1994), 362.

[385] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 260.

Importantly, the submarine threat was not solved by the tactical solutions of convoys alone. Technological counter-measures—the mirror image of diffusion—had advanced in the 16-month lull afforded by German acquiescence. Depth charges, antennae mines, primitive underwater "hydrophones," and asdic (an early precursor to sonar) made the threat of detection, destruction, or both more likely, although, still exceedingly difficult. By July 1917 convoys combined with the developing anti-sub technology had reduced the amount of shipping loss to a manageable level[386] Germany had allowed international pressure to influence their abandonment of a revolutionarily integrated form of combat.

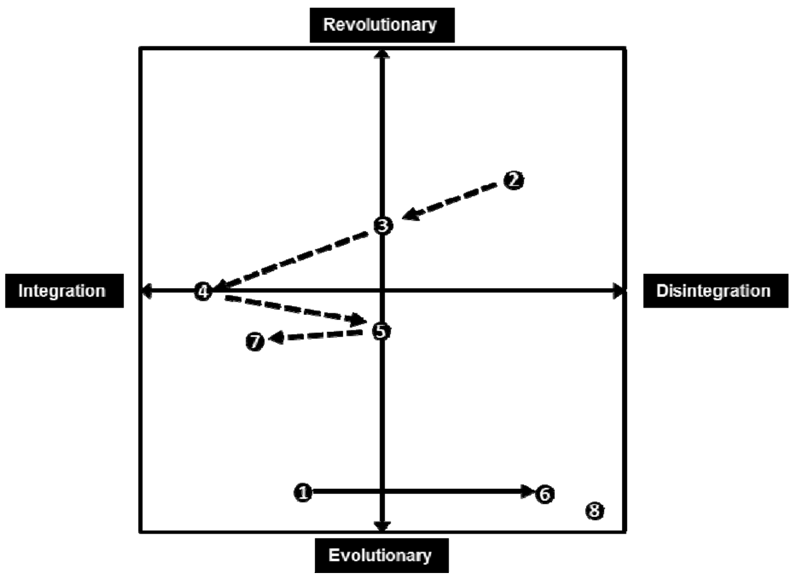

Figure 5. Figure showing German submarine (dashed) and British surface techno-strategic integration during the Frist World War.

Battleships at the start of the war (Point 1) had undergone a series of rapid evolutionary developments from 1896 to 1914; they were integrated into doctrinal paradigm stressing control of the sea. However, control of the sea was no longer confined to the surface. Submarines at the start of the war (Point 2), were still relatively revolutionary, and posed a significant problem for integration into the existing paradigm because their slower speed prevented them from being easily incorporated into the

[386] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression,* 261.

existing fleet concept. However, Germany perhaps pressured from a position of naval inferiority across all ship types was willing to experiment more with alternative doctrinal concepts that increased the role of submarines. Germany started integrating some of the asymmetrical advantages of submarines early in the war (Point 3) against British warships. However, further integration was achieved when Germany declared unrestricted submarine warfare in February 1915 (Point 4). The effectiveness of the new techno-strategic paradigm, embodied by submarines and commerce raiding, combined with an inability of the old paradigm to counter it militarily. Diplomatic condemnation, which was perhaps fueled by the radical paradigm shift, was sufficient however to get Germany to temporarily relinquish its advantage (Point 5). The threat alone of a subsurface attack whether from another surface ships torpedoes or from a submarine was enough to force Jellicoe to turn away—battleship's represented a huge investment, they may have been too big to fail. At Jutland the lack of decisive victory provides further proof of the disintegration of the techno-strategic paradigm of battleships and control of the sea (Point 6). Jutland's indecisiveness and the extensive damage suffered by the High Seas Fleet acted like a conversion experience for Scheer who recommended the resumption of unrestricted submarine warfare following the engagement. Germany did resume unrestricted submarine warfare (Point 7) in February 1917, but by then diffusion of the paradigm had prompted both tactical and technological counters limiting which eventually limited its effectiveness. Finally, battle cruisers (Point 8) provide an interesting example of disintegration by design. Thirty-three percent of the British battle cruisers fleet was destroyed at Jutland. Battle cruisers were built around a concept of long range gunnery; a capability that because of competing optical range finding acquisition choices they did not have.

E. SUMMARY

Leading into the First World War, poor civil-military relationships in both France and Germany encouraged both countries' militaries to promote an institutionally-favored doctrine of offense which would prove, tragically, to be the wrong choice. However, the offensive strategies of the time favored mass. The Prussian innovations in techno-strategically integrating railroads to mobilize the huge armies made possible by the

conscription systems had diffused following the Franco-Prussian war. The diffusion of rapid mobilization prevented the rapid capitalization of France which was crucial to the success of the Schlieffen plan. Rapid mobilization had failed to achieve victory and soon the inherent defensiveness of machine gun and artillery technology increasingly made offensive strategies of mass untenable. Techno-strategic reconciliation on the western front broadly took two forms. The British sought a technological solution that offered protection, firepower, and mobility, thus, the tank was developed. During the rest of the war the tank would simultaneously be improved technologically and integrated doctrinally. Although Germany did imitate by building, tanks, during the war their efforts were limited due to widespread material shortages. However, Germany reinvigorated their offensive doctrine with a reformulation of the techno-strategic integration of machine guns. Their doctrinal innovation was to use the machine gun in as the technological centerpiece of infiltration tactics—dispersion against mass. Interestingly, both tanks and a doctrine of dispersion were prompted by the need for protection. Lawrence and Lettow-Vorbeck were showing how, in other theaters, dispersion was also playing a role in an entirely different form of techno-strategic integration. These “masters of irregular warfare” were using the concentration of destruction made possible by technology against the techno-strategic integration of their opponent’s reliance on rail showing how the relationship between capability and vulnerability can be exploited.[387]

At sea the history of naval tradition was being tested by a new threat that had shifted control of the sea from a two-dimensional paradigm to a three-dimensional paradigm. Rapid and increasingly expensive evolutionary development occurred prior to the war in the paragon of sea control—the battleship. But on the whole the performance of battle ship during the war was inconclusive; they were vulnerable to underwater attacks and lacked the expendability needed for audacity. Also, on the surface, battle cruisers show one example of how a techno-strategy can be disintegrated by design. In this case, the battle cruiser represented a system of technologic advancements that

[387] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*.

seemed to make a nimble big gun ship nearly invulnerable—as long as it remained out of range. But the lack of a targeting sight capable of engaging targets at the range necessary to safeguard the lightly armored vessel instead made battle cruisers unsuited to their task. Meanwhile, submarines were offering a novel techno-strategic solution to conducting naval warfare. In this example there is further evidence of the benefits of attacking an adversary's techno-strategic integration. Doctrines of mass and attrition require stores of materials, by engaging in unrestricted submarine warfare Germany was attacking its enemy's ability to wage war—a concept that would also be pursued aerially. Also, this example shows the revulsion inherent in a paradigm shift. The diplomatic pressure Germany faced because they were pursuing a new type of war is eerily similar to the condemnation of terrorist and other asymmetric adversaries who may merely be exposing our weakness to their reformulation of techno-strategy. Although, Germany was initially persuaded to abandon their one form of revolutionary integrated techno-strategy their eventual resumption of unrestricted submarine warfare indicates that it is unrealistic to assume that international sanctions alone will be enough to counter new techno-strategic paradigms.

Like submarines, airplanes extended into a third dimension, and would come to play an ever larger role in combat. Naturally filling the need for reconnaissance airplanes soon showed promise in a variety of roles. As the different technological requirements of the various roles became apparent increasing specialization of the form was evident in the evolution of fighters and bombers. Although, airpower alone was not sufficient to break the stalemate of the western front it would become increasingly necessary component of offensive techno-strategic integration. Airpower too, in the bomber archetype, promised to threaten the enemy's ability to wage war. Unlike submarines, which could only target materials airplanes seemed to offer the capability to target production, and possibly, through terror, civilian support for war itself.

Information was also becoming more important. As doctrines of mass gave way to doctrines of dispersion informational requirement increased as it became more difficult to "know" where friendly and enemy units were on the battlefield. The rudimentary wireless radios and cable bound telephones of the First World War limited the flow of

information. However, the continued evolution of communications technology was already starting to make itself known. The German interception of Russian communications transmitted in the open at Tannenberg led to a resounding Russian defeat.[388] As communications developed they would offer, like all technology, a capability and vulnerability. Already at Jutland, and in other cases, radios were being used as much to misinform the enemy as they were to inform other friendly units. Furthermore, the development of direction finding equipment, and encryption was a burgeoning frontier of revolutionary technology by the conclusion of the First World War. "Plan 1919," was unnecessary, had it been executed it may have been the final proof that the paradigm on land had shifted just as dramatically as it had on sea. It was built around techno-strategic capabilities and doctrines that had not existed at the start of the war, but had become necessary as the disintegration of the current paradigm became apparent in the trench lines.[389] In the intervening years between world wars the techno-strategic integration of the new paradigm, evident at the conclusion of the First World War, was broadly pursued. As the ramifications of the armistice exerted their subtle pressure on both the victors and the vanquished it became apparent that the test of integration would soon be at hand.

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388 Meyer, *A World Undone: The Story of the Great War, 1914–1918*, 170.

389 McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000*, 334.

IV. THE INTERWAR PERIOD AND WWII

By the conclusion of the First World War some of the dissonance between offensive doctrines and early twentieth century weapons had been resolved. Techno-strategic integration on land had returned mobility to the battlefield. At sea the Mahanian paradigm of positive sea control produced by decisive engagements between surface fleets was facing serious threats from submarines. The nascent technology of airplanes was increasingly influencing combat on both land and at sea. Many of the defining technologies of the Second World War—tanks, battleships, submarines, airplanes, aircraft carriers—existed by the conclusion of the First. New technologies were on the horizon as well and, none would eventually be more ubiquitous than radar or more lethal than nuclear munitions. Furthermore, the scale of the First World War ensured broad exposure to the technology and strategies developed during the conflict, providing a historic backdrop for future imitation and continued development. However, the magnitude of the conflict, while ensuring exposure, seems to have prevented a uniform analysis of what future war would look like. Organizational biases, war weariness, and financial constraints would all influence the process of techno-strategic integration during the interwar. The interwar years, a period of intense strategic competition, post war reflection, and imitation in England, Germany, France, America and Japan, provides a unique environment to survey the techno-strategic integration of the emerging technologies of WWI. The Second World War, seen in this light, provides a litmus test regarding how well each participant integrated the new technological forms.

As the strategic environment became clearer toward the latter half of the 1930s, Germany and Japan benefited from their early rearmament and combat experiences. Germany, vanquished and punished under the Treaty of Versailles, had deeply reflected on the experience of the First World War. Its military had solved many of the operational problems of integration, and their application of what they had learned shocked the world in 1939. Perhaps though, by looking so hard at the past they failed to appreciate the future—their operational success would not translate to ultimate victory. Japan also showed early promise, but was ultimately undone. Their military expansion, having been

checked at Midway, would prove to be unsupportable by their resource base. The United States and Soviet Union were outclassed initially. The imitation of German practices and rapid diffusion of technology would change the allied armies. Although the course of the war was changing before the balance of material production shifted, the unparalleled ability of the Soviet Union and the United States for production would eventually overwhelming favor the allies

A. NAVIES

1. Tough Choices: Battleships, Aircraft Carriers, and Submarines

At the conclusion of the First World War navies faced tough choices. To naval establishments, battleships were a historically tried and true technology. Yet battleship performance in the First World War did not deliver decisive results, and there were evidence that the techno-strategic foundations underpinning two-dimensional control of sea control was inadequate. It was also true that Britain's more numerous and more advanced battleship fleet had effectively blockaded Germany. To the same degree that battleships were favored by navies, submarines were hated. However, they had shown some potential during the First World War and would continue to capture the imagination of some naval officers. During the interwar period submarines faced existential challenges in naval disarmament talks, were technically redesigned to support fleet operations, and eventually reemerged in the Second World War in the same role they had performed in the First. Although the carrier *HMS Argus* debuted in 1918 and the Royal Navy produced 12 aircraft carriers during the First World War, aircraft carriers represented a relatively unknown frontier for navies.[390] None of the three forms necessitated the abandonment of either of the others. Therefore, the interwar years represented a technological crisis to navies as they tried to decide upon the right fleet composition and what technical qualities of each of the three macro designs.

Civil-military relations affected techno-strategic integration through three major interrelated factors immediately following the war although each country experienced

[390] Geoffrey Till, "Adopting the Aircraft Carrier," in *Military Innovation in the Interwar Period*, eds. Williamson Murray and Allan Reed Millett (New York: Cambridge University Press, 1996), 191–194.

them differently. First, on the political side, international treaty obligations resulting from a series of successive naval disarmament conferences started impacting the quantities of warships being constructed by type. Also certain qualitative limitations such as displacement were established, impacting the force compositions that naval leaders had to plan against. In some ways this favored the development of aircraft carriers as battleship were converted to flattops to meet treaty requirements. Second, financial constraints were prevalent as countries struggled to pay off their debts from the First World War, and later from a global depression. Both affected defense spending. Although, financial considerations were one of the primary reasons many of the treaties limiting naval expansion were sought, it is also worth considering independently because austerity sometimes prevented building to treaty strength. Finally, on the military side, there was a lack of consensus on which technology to choose. The resulting organizational struggles are beneficial in highlighting some of the difficulties in adopting new techno-strategic concepts.

The Treaty of Versailles, with its limitations on Germany's post First World War naval composition, in some ways, began the process of international naval arms restriction that would continue through the 1920s. However, soon after the war Japan started planning to construct 40,000-ton ships, prompting the United States and Britain to lay down their own plans for ships of equal or larger size—it appeared as though the bell had rung starting the next round of the naval arms race.[391] As evidenced by their post-war building programs, navies in all three countries had reverted back to the organizationally familiar techno-strategic paradigm of battleships and control of the sea. However, there were factions that were starting to question the battleships role. In 1921, William Mitchell, an early and ardent air-power promoter, was able, after relentlessly pressuring the navy, to test whether aerially delivered munitions could sink the captured German battleship *Ostfriesland.*[392] Mitchell's airplanes were successful; furthermore, Mitchell was in correspondence with Admiral Sims who, as head of the Naval War

[391] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle,* 102.

[392] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression,* 271.

College, had independently determined the latent power of aircraft carriers through war gaming.[393] Importantly, the U.S. Secretary of State, Charles Evans Hughes had also been informed of the testing.[394]

Over the New Year between 1921–1922, at the Washington Naval Conference Secretary Hughes staked his knowledge regarding the battleship's uncertainty as a means of an arms control agreement between the United States, Britain and Japan that would fix overall tonnage ratios between the three powers at 5:5:3; individual battleship size would be limited to 35,000 tons.[395] Aircraft carriers were allotted more overall tonnage which was set at 135,000 tons for the U.S. and Britain and 81,000 tons for the Japanese.[396] Submarines faced existential challenges particularly from the British, however, failing to get rid of them, the conference instead tried to regulate their actions by ensuring that future submariners understood that the laws of "visit and search" still applied.[397] A ten-year naval holiday ensued following the Washington Conference, and although there were additional conferences through the interwar it was the Washington Conference that set the tone. The main financial difficulties of entering into another naval arms race following the First World War had been averted through political negotiations. While treaty obligations limited what *could* be constructed; financial pressure limited what *would* be constructed. Only the Japanese would build up to and, as a means of bargaining future strength by appealing to current strength, beyond treaty authorizations by the London Conference in 1930.[398] Japan moreover, became increasingly antagonistic toward negotiations as their negotiated position of inferiority was at odds with their growing nationalism and burgeoning desire for imperial expansion.

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[393] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 271.

[394] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 271.

[395] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 272; Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 102.

[396] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 272.

[397] Holger H. Herwig, "Innovation Ignored," in *Military Innovation in the Interwar Period*, eds. Williamson Murray and Allan Reed Millett (New York: Cambridge University Press, 1996), 242.

[398] Robert L. O'Connell, "Life After the Death: Rehabilitating the Dreadnought," in *Sacred Vessels: The Cult of the Battleship and the Rise of the U.S. Navy* (New York: Oxford University Press, 1993), 291.

In the absence of international treaties it is reasonable to assume, based on post-war building plans that another iteration of battleship construction would have ensued. Furthermore, the evolutionary trends toward marginal improvements in tonnage and gun size were already evident in the construction plans of both the Japanese and the U.S.. This indicates that it may be plausible that in an atmosphere of strategic pressure militaries will fall back of the traditionally tried and true weapons even in light of growing indications that the techno-strategic paradigm may be shifting. When Secretary Hughes, who had perhaps become aware that battleships *may* not have had sole claim to sea control, and offered a political solution to slow down strategic competition. He not only effected financial savings, he also bought time for navies to figure out, in general, what future naval combat would look like. It now became incumbent on navies to use that time within the limitations of resources to develop their concepts of techno-strategic integration.

The navies of the United States, Britain, Japan, and Germany differed contextually in the conditions within which techno-strategic naval decisions were made. By illuminating the effects of those differences on the techno-strategic integration of aircraft carriers, battleships, and submarines, some best practices were derived. Furthermore, all three vessel archetypes were in some way tested against the prevailing doctrinal concept of Mahanian control of the sea that was still operating in each of these countries. The persistence of this idea in itself is illuminating because it shows the difficulty inherent in a paradigm shift—until there is a new explanatory concept the old one will always carry weight.

In the United States Navy fleet composition decisions were governed in large part by recommendations from the General Board. The General Board occupied a somewhat unique position within the U.S. Navy at the time. They were senior in rank, but not involved in the daily operations of the Navy. Following the *Ostfriesland* test, and the Washington Naval Conference, the U.S. Navy began further experimentation with aircraft and battleships. However, much of the testing was controlled by the navy. The navy's subsequent stipulations and management of the presentation of the results reveals the organizational preference for battleship. The Washington Treaty's tonnage

limitations made some older ships available for testing as the navy drew down to treaty specifications. By looking at the audiences invited to the tests the navy's strategy to preserve battleships is clear. In general, for tests using planes, whether armed with torpedo or bomb, as were conducted against the *Arkansas* and *Alabama*, no members of the General Board were present.[399] Meanwhile, the tests emphasizing the power of battleships to sink battleships were replete with senior officers, General Board members, and press.[400]

However, Billy Mitchell had caught the attention and imagination of the public. Mitchell's flamboyance and deliberate manipulation of public opinion through barnstorming airshows put him at odds with the U.S. Navy's Admiral , who was the navy's senior airman.[401] Moffett effectively established the Bureau of Aeronautics (BuAer) one year after taking over responsibility for naval airpower in 1920—an extremely shrewd move that put naval aviation on equal footing with the other naval bureaus and provided a measure of protection against competing interest.[402] Mitchell may have overstated his case, but his style could not be ignored. The House convened inquiries into Air Service Operations, first in the Lampert Board and then followed up in the Morrow Board.[403] Mitchell who was crusading for an independent Air Force, may have been instrumental in drawing political attention to the power of air forces, but he proved to be unwilling to accept anything less than the acceptance of his ideas and, in the end, his agitations would result in his court martial and retirement in 1925. Meanwhile Moffett, a Medal of Honor recipient with a career of service on battleships would, through his more moderate approach, make significant advances on both aspects of technology and strategy; however, he would do it from within the organization. Following the investigations by the House the Navy General Board convened its own inquiry into naval air operations. Presided over by the Chief of Naval Operations Edward

399 O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 278.

400 O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 278.

401 Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 250.

402 Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 250–251.

403 O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 279.

Eberle, the committee was predominately stacked against aviation—there were no aviators on the panel.[404] The seven recommendations coming out of this board were presented to President Coolidge as priorities for investment; therefore, these recommendations represented the "official" navy position regarding which vessels would characterize future naval engagements.

	Eberle Board's Recommendations
1	Modernize the six oldest battleships
2	Complete construction of the aircraft carriers *Saratoga* and *Lexington*
3	Modernize the remaining battleships
4	Construct eight 10,000- ton cruisers
5	Acquire aircraft
6	Construct six submarines
7	Construct an additional aircraft carrier

Table 2. Eberle Board's seven recommendations to President Coolidge (From[405])

Although favoring battleships, the recommendations appear to indicate a broad technological approach, however, underlying the spending priorities was a techno-strategic approach that kept both aircraft carriers and submarines in supporting roles. For carriers that meant supporting the fleet with reconnaissance aircraft, and for submarines it meant screening for the fleet. However, by not rejecting any warship type the Eberle Board at least encouraged continued experimentation.

Britain's carrier program, in contrast, was falling behind. At the end of the First World War the Royal Navy had invented the refined form. The Royal Navy had produced the first carrier capable of both launching and landing aircraft—the *HMS Argus*.[406] Furthermore, at the conclusion of the First World War they possessed more aircraft carriers, and were more proficient at carrier operations, than any other country. It is of particular interest that they lost their early advantage. Financial constraints certainly played a role, but were a constant between countries, therefore, additional evidence must be considered. The Royal Navy's early lead worked against future innovation. In America, Moffett, as the chief of BuAER, was busy developing supporting technologies,

[404] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 279.

[405] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 280.

[406] Till, *Adopting the Aircraft Carrier*, 194.

such as, launching catapults, tail-hooks, and arresting wires as well as researching aircraft engines.[407] The British, having the early numerical advantage, were lulled into a false sense of superiority and were content to and were willing to let others do the innovating.[408] Had the British been able to time a rapid build-up when they needed it, this strategy may have turned into a brilliant attempt to leverage the advantages of late modernization, but as Geoffrey Till notes "Britain's relative industrial decline and severe financial difficulties were the real reasons for the deficiencies in the Britain's carrier program."[409] For the British that meant that when the requirement for carriers presented itself clearly, they had already fallen so far behind that they were not able to capitalize on late modernization but instead remained irreparably behind. By 1926 and 1933 the British would be surpassed numerically by the American and Japanese respectively, and by the start of the war in 1939 the British would field just over 400 naval aircraft some of which were not even exclusively tasked to maritime duty.[410] In contrast, both America and Japan were able to field over 600.[411]

Another significant difference that may have been at work relegating Britain to third place in the interwar development of aircraft carriers was that unlike Japan and America, Britain established the Royal Air Force (RAF) and an Air Ministry—a separate service under a separate civilian minister. In part this was the logical result of the strategic environment each of the three nations faced as the interwar progressed. Japan and America could increasingly look toward each other as strategic competitors in the vast Pacific. The planes needed in the Pacific theater would have to be brought to the battle, and the expansiveness of the ocean itself validated the early role assigned to naval aviation of performing reconnaissance for the main battle fleet.[412] England, on the other hand, faced strategic ambiguity and the continuing commitments of it waning empire. Furthermore, England's global position made strategic bombing a more likely possibility,

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[407] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 253.

[408] Till, *Adopting the Aircraft Carrier*, 198–199.

[409] Till, *Adopting the Aircraft Carrier*, 199.

[410] Till, *Adopting the Aircraft Carrier*, 199.

[411] Till, *Adopting the Aircraft Carrier*, 202.

[412] Till, *Adopting the Aircraft Carrier*, 203.

a claim that the RAF used to justify the production of bombers over maritime aircraft. As Germany’s naval power increased in the early 1930s England could look to them as a primary competitor and envisage naval operations in support of its shipping routes and in defense of it shores—the aircraft needed for support in this concept could be based on the ground in Britain.[413]

Also, as a result of Britain’s creating a separate air service, the Royal Navy lost a large portion of their war experienced talent, as navy aviators stood up the Royal Air Force in 1918.[414] The loss of these aviators created a leadership gap within the Royal Navy’s Fleet Air Arm. The young aviators had no senior leaders to provide mentorship or to create an environment conducive to experimentation. This problem was exacerbated by the Royal Navy’s insistence that carriers be commanded by general service officers.[415] Also a factor was the organizational system that developed where the Royal Navy’s aviation initiatives were dually controlled by the Admiralty and the Air Ministry.[416] The RAF, which controlled the development of all aircraft, quickly established precedence for its preferred fighters and bombers over maritime use planes, and the Fleet Air Arm, lacking an air minded senior officer, was unable to adequately advance the Royal Navy’s naval aviation needs.[417]

In contrast one of Moffett’s most prescient changes was to leverage the findings of the Morrow Board to get congressional support behind his initiative to make aviator qualification a requirement for carrier commands.[418] This incentivized senior career minded officers such as Ernest J. King and William F. Halsey—both would be instrumental in the Pacific theater during WWII—to obtain aviation credentials to make them competitive for the broadest number of potential command opportunities. By enticing senior officers Moffett was able to expose a larger portion of the navy to the

[413] Till, *Adopting the Aircraft Carrier*, 200–201.

[414] Till, *Adopting the Aircraft Carrier*, 207.

[415] Till, *Adopting the Aircraft Carrier*, 207.

[416] Till, *Adopting the Aircraft Carrier*, 208.

[417] Till, *Adopting the Aircraft Carrier*, 208–209.

[418] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 253.

ideas of naval aviation. Whether these men went on to command carriers was not necessarily the more important or lasting impact of this initiative; rather, Moffett ensured the propagation of U.S. naval aviation by creating a vanguard of senior officers who, through counsel of their subordinates, would nurture the idea.

Japan's early forays into naval aviation experienced some of the same challenges of decentralization that were experienced in Britain.[419] However, in 1927 the Japanese established a headquarters for naval aviation that was independent from, but reported to, the naval minister.[420] Furthermore, as in America, some of Japan's senior admirals—notably Admiral Yamamoto as vice navy minister from 1936–1939—encouraged development of naval aviation.[421] Geoffrey Till credits "The revolution in naval administration which began in 1927 as explaining the impressive surge in the development of Japanese naval aviation from the mid-1930s."[422]

The U.S. Navy's exposure of officers to naval aviation and the advocacy enabled by creating an independent BuAER headed by a flag officer may have directly contributed to the willingness to experiment with new approaches to carrier doctrine. The completion of the *Lexington* and *Saratoga* in 1928 provided the test subjects. These carriers were capable of 34 knots and housed up to 80 aircraft each.[423] In 1929, during an exercise dubbed Fleet Problem IX, both the *Saratoga* the *Lexington* participated, but on opposing sides.[424] However, it was the *Saratoga's* actions that were notable. Working in conjunction with the cruiser *Omaha*, the *Saratoga* separated from the main battle line and launched its planes 140 miles away from the intended target, which for the purposes of this exercise was the Panama Canal.[425] The planes easily achieved their objective of bombing the Miraflores Locks; unfortunately, the decisiveness of the

419 Till, *Adopting the Aircraft Carrier*, 212.

420 Till, *Adopting the Aircraft Carrier*, 212.

421 Till, *Adopting the Aircraft Carrier*, 213.

422 Till, *Adopting the Aircraft Carrier*, 213.

423 O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 283.

424 O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 285.

425 O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 285.

exercise was jeopardized when the *Saratoga* was “sunk” as it moved toward the target area to land its aircraft.[426] However, Admiral William V. Pratt the overall exercise commander took note of what the *Saratoga* had achieved. Pratt, although impressed, wanted further testing and in 1931 in his role as Chief of Naval Operations (CNO) he oversaw Fleet Problem XII.[427]

Unfortunately, the aircraft carriers *Lexington* and *Saratoga* were unsuccessful in stopping the fleet’s landing force during Fleet Problem XII, which cast doubt on the overall viability of a carrier-centric task force, and Pratt found himself in the position of having to use the results of Fleet Problem XII to secure funding for battleship modernization.[428] However, given that wartime performance would invalidate the conclusion that “The battleship is the backbone of the fleet,” questions regarding the nature of the test become important as it had rendered a false positive.[429] Two factors may have contributed to the problem of using this as the deciding test. First, the odds were deliberately stacked against the carriers. Second, since carriers were a relatively new addition, their employment doctrine was not completely worked out. During the problem the carriers split into two groups, and were unsuccessful largely because their planes could not locate the opposing force. At best this represents an operational problem, not a strategic weakness; furthermore, it was an operational problem increasingly less pertinent in the late 30s as radar became increasingly available. However, the naval hierarchy would not be seriously challenged again until after Pearl Harbor.

All navies remained tied to a conventional approach to naval operations characterized by the teachings of Mahan and the superiority of the battleship. Pearl Harbor the sinking of *Prince of Wales* and *Repulse* would rapidly shift perceptions among naval leaders. Aircraft carriers would eventually surpass the battleship, but during

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[426] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 285.

[427] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 286.

[428] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 286–287.

[429] The quote is from William V. Pratt from material in O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 286.

the interwar period, their value was perceived in terms of how well they could be thought to support the main battle fleet. In that respect aircraft carriers, although initially subordinated to battleships, fared much better than submarines. Although not abandoned, the American submarine program during the interwar was a low priority—when the U.S. needed an alternative concept of operations following the destruction of the battleship fleet at Pearl Harbor the submarine force would be there. As already indicated, submarines were sixth out of a list of seven priorities for the U.S. Navy. Furthermore, the V-class fleet submarine was a deliberate attempt to subordinate the submarine to a techno-strategic concept it was unsuited for—supporting fleet operations—yielded a submersible chimera. The six V-class submarines were poor divers and too slow to support fleet operations, but they represented the entire effort of the U.S. Navy during the 1920s.[430] However, it is hardly surprising that the U.S. Navy initially failed to techno-strategically integrate submarines with a concept of operations emphasizing commerce raiding. At the Washington Conference U.S. political leaders had argued violently for increased restriction regarding the rules governing search and seizure. There was simply no indication politically that the U.S. Navy would be asked to perform this mission, although Pratt, again showing his insight, noted that the agreed upon conventions for submarine use were "made to be broken."[431] Subsequently, with the failure to morph the submarine into a suitable accoutrement of the fleet, the General Board recommended that submarines be eradicated altogether at both the Geneva and London Conferences in 1927 and 1930 respectively.[432]

By 1935 the U.S. was 18 submarines under treaty authorizations and behind Britain and Japan in terms of total numbers.[433] The Naval War College, however, was experimenting with different concepts of operations in their war gaming during the early 1930s and, as a result, there started to be reenergized thinking regarding the best

[430] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 281; Herwig, *Innovation Ignored*, 254.

[431] Herwig, *Innovation Ignored*, 255.

[432] O'Connell, *Life After the Death: Rehabilitating the Dreadnought*, 282.

[433] Herwig, *Innovation Ignored*, 255.

employment for submarines.[434] Also, by the late 1930s the U.S. Navy could be increasingly confident that it was on a collision path with Japan. Japan had withdrawn from the 1935 London Naval Conference after demanding parity, and started a major war in China in July 1937. Furthermore, the assault on Manchuria, conducted by 264 planes supported by three aircraft carriers, showed better than any fleet problem or war-game both the power of aircraft carriers and how advanced both Japan's fighters and pilots were.[435] As Japan's naval power became apparent, senior naval leaders realized that War Plan Orange—the standing plan for war with Japan--was no longer viable due to technological advances. By October 1940 Orange was undergoing a transformation, and when it emerged as War Plan Rainbow Five in May 1941 it included provisions for commerce raiding.[436] Assisting this change with a theoretical underpinning and representing the ultimate of ironies, Admiral Edward C. Kalbfus in his duties as president of the Naval War College had reevaluated the German WWI practice of declaring war-zones, and had determined that it was a viable practice.[437] Although Kalbfus's recommendation was rejected, it was only a matter of justification not tactics. Japanese merchant ships could be attacked under the presumption that they were armed and therefore a legitimate naval target.[438] Fortunately, for the U.S. Navy, the *Tambor* class submarine provided a technology that could complement the reformulation of strategy following Pearl Harbor on December 7 1941. The *Tambor* was a superior class of submarine; larger than its German counterpart, it was powered by four diesel engines allowing it to charge its batteries while underway, and it also incorporated a firing computer that assisted torpedo accuracy.

Charles A. Lockwood's persistence, as a relatively junior officer while serving in Washington as the submarine desk officer in 1937, was instrumental in the development of the *Tambor* class submarine, which was opposed by the General Board and by

[434] Herwig, *Innovation Ignored*, 255.

[435] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 123.

[436] Herwig, *Innovation Ignored*, 256–257.

[437] Herwig, *Innovation Ignored*, 257.

[438] Herwig, *Innovation Ignored*, 257.

Admiral Thomas Hart.[439] Lockwood's, involvement again highlights the power of individual leadership to enact techno-strategic transformation. Lockwood, following a tour early in the war as a naval attaché in London, returned to sea duty as a rear admiral in March 1942.[440] As a commander Lockwood proved adept at both advocating to higher authorities for the benefit of his forces, and selecting the type of talent his operational concepts required. The *Tambor* class of submarines may have been the best in the war and the accuracy of a computer enhanced targeting system was highly advanced, but the Mark-14 torpedo was nearly useless. Under the province of the Bureau of Ordnance (BuOrd) the Mark-14 suffered two major flaws—it ran too deep, and its magnetic fuse was so fragile that it was usually destroyed before it could detonate the warhead.[441] In contrast the Japanese Long Lance torpedo was a technical masterpiece; fueled by liquid oxygen it could travel at 49 knots for distances up to 11 miles, and was truly a formidable threat.[442] The technical malfunctions with the Mark-14 torpedoes were a result of the BuOrd's failure to test it during its development and fielding under combat conditions, a decision based on specious financial arguments. Even in light of reports from the field, including those of senior leaders like Lockwood, BuOrd was slow to address the torpedo's failings, choosing instead to question crew competence. Eventually, by the summer of 1943, the torpedo problem was rectified, but it is reasonable to question how much money and lives were lost trying to save money in testing and development.

Advocating for his sailors made Lockwood a good commander, but what made him great was his ability to envisage a techno-strategic fusion of the submarines that took advantage of its strengths to perform operations like commerce raiding, assisting guerrilla operations, and reconnaissance.[443] Lockwood was able to achieve his vision for submarine operations in part because he uncompromisingly selected and retained his

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439 Herwig, *Innovation Ignored*, 258.

440 Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 194–195.

441 Herwig, *Innovation Ignored*, 259–260.

442 Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 123.

443 Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 196.

subordinates based on their suitability to perform within his concept of operations. Although the U.S. Navy did not, for the majority of the interwar period, plan to conduct unrestricted submarine warfare, they were able to when the situation arose largely due to his efforts. Senior leaders such as Lockwood were able to nurture alternative strategies against the conventionally minded thinking of the majority, and were, therefore able to present options when the time came. Other navies, notably the British, were not as fortunate.

The British and the German cases present an examination in opposites. To characterize the general dispositions of these navies' approaches to the development of submarines during the interwar: the British were unwilling but able, and the Germans were willing but unable, at least, initially. The Germans managed to brilliantly stay on the cutting edge of technical and tactical developments in spite of the Treaty of Versailles, which had forced them to give up their 176 U-boats at the conclusion of the First World War and also prevented them from constructing or obtaining new *Unterseebooten*.[444] The punitive tone of the Treaty of Versailles, which necessarily forced *any* German submarine program into secrecy, may have directly increased collusion in civil-military relations. Two separate secret funds each administered by a captain were created from money garnered in the forced sales of it ships following the treaty.[445] As early as 1922 the money was invested in collusion with the major industrialists of Germany into a front company in the Netherlands to design and build submarines.[446] While the final product would be built offshore, the Germans would "build" submarines for a variety of countries using designs from German engineers, and with parts from German manufacturing throughout the 1920s.[447] This arrangement ensured German capability to design and produce a technically modern submarine and also facilitated diffusion.

[444] Herwig, *Innovation Ignored*, 231.

[445] Captain Walter Lohmann administered the "Special Fund" and Captain Gottfried Hansen administered the "Black Fund." Herwig, *Innovation Ignored*, 231.

[446] The Company's name was N.V. Ingenieurskantoor voor Scheepsbouw: Herwig, *Innovation Ignored*, 232.

[447] Herwig, *Innovation Ignored*, 232.

As the restrictions of Versailles lessened, through flagrant disregard or through negotiations, the clandestine investment in design and manufacture enabled Germany to rapidly build its submarine forces. The political injunctions were mostly overcome after 1935, based of stipulations in the Anglo-German Naval Agreement that allowed Germany to resume submarine construction up to 35 percent of Britain's—by 1938 Germany had 72 U-boats either completed or in construction with the majority in construction.[448] Doctrinally however, the role of the submarine was unclear. In Germany, as elsewhere there was a continued adherence to the Mahanian concept of operations emphasizing fleet action. This limited experimentation with alternative concepts of operations. However, unlike other navies there was a core of experienced submariners that had participated in Germany's commerce campaign in the First World War. Karl Dönitz, who in 1936 would become the "Commander of U-boats," often found himself at odds with his superior Erich Raeder. By the late 1930s, Raeder, supported by staff analyses, postulated that submarine effectiveness had been reduced by countermeasures, and was therefore better suited for the more defensive role of protecting commerce. Commerce raiding would be performed by *Panzerschiffes*—an armored cruiser.[449] Germany despite having the most experience in the First World War remained wedded to the battleship—an abject failure of learning. Some had the foresight to see the possibilities. Dönitz for example was training his submarines to operate using "wolf pack" tactics group of submarines would converge on and destroy a target. In contrast, Lockwood's similar concept of operations emphasized individual submarines rather than packs—a difference that maximized the probability of locating targets by casting a larger net.[450]

The Royal Navy also suffered from a failure of analysis, which in their case was compounded by organizational rigidity and a steadfast belief that the interwar resolutions would be upheld. Having "won" the war, the Royal Navy focused it intellectual efforts on re-fighting Jutland and slowly convinced itself that Germany's submarine warfare

[448] Herwig, *Innovation Ignored*, 236.

[449] Herwig, *Innovation Ignored*, 238.

[450] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 195.

campaign had not really been that threatening. This nonchalance toward submarines was institutionalized through the officer professional education system; by 1934 the Royal Navy's staff college spent three days examining Jutland—the battle itself had lasted less than two days.[451] The few serious analyses regarding submarines and the course of naval combat during the First World War were deliberately restricted by the Admiralty to protect the service's image.[452] Another variable preventing serious analysis in the Royal Navy was their unfounded faith that they had solved the problem of submarine detection through the advent of asdic. An early precursor to sonar, asdic was online by 1917. Although, asdic was a remarkable achievement, it inspired confidence that far exceeded its capacity. Furthermore, like the *mitrailleuse* the secrecy that surrounded asdic prevented it from being seriously tested.[453] Asdic turned out to be more placebo than panacea, but the idea that a technical solution like asdic existed fostered the Admiralty's unwillingness to seriously question the impact that submarines would play in future wars. Although naval operations during the Spanish Civil War in 1936 revealed some of the shortcomings of asdic, the Royal Navy was still claiming detection rates of 80 percent in 1938.[454] By no means was asdic useless. It was effective, but its effectiveness was limited by its capabilities at the time. From the standpoint of techno-strategic integration it is useful to consider whether an environment of technological experimentation with asdic would have benefited the Royal Navy which through exploring the capabilities of the device may have been able to minimize its limitations through further technical and doctrinal innovation.

Radar offered a different technological capability to gather information about positional locations. Its focus in contrast to asdic was in the air and on the surface instead of underwater. The appeal and power of information explains why radar would become nearly ubiquitous during the war. Radar preceded the Second World War, and was independently being researched by all the major participants. Germany was at the

[451] Herwig, *Innovation Ignored*, 248–252 .

[452] Herwig, *Innovation Ignored*, 248.

[453] Herwig, *Innovation Ignored*, 247.

[454] Herwig, *Innovation Ignored*, 246; Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 111.

technical forefront in the 1930s, and at the outbreak of the war was ahead in areas of resolution, ruggedization, and versatility.[455] Radar was also finding applications in enhancing naval gunnery. Germany's early lead would not lead to the best techno-strategic integration. Germany's technical superiority would begin to diminish in 1939 when the decision was made to focus continued developmental efforts on the longer wavelength end of the spectrum.[456] Centimetric, or microwave radar was harder to power and thus suffered from shorter ranges, but eventually those difficulties would be overcome by the allies. Radar was a key enabling technology in that it dramatically altered the capabilities, both offensively and defensively, of a variety of weapons systems. Accordingly, the techno-strategic integration of radar would yield major result to battles at sea, in the air, and against aircraft. Radar was just one area of the growing enterprise of intelligence. Other technologies, such as radio, proved immensely useful for commanding and controlling military forces. However, while the radio offered an unparalleled means of command and control its advantages came with the vulnerability that it could be intercepted and exploited. Encryption seemed to offer the necessary safeguards, but the incentive of knowing the enemy's mind and the abilities of cryptologists to crack even the toughest cyphers proved more effective than communications security procedures. Both radar and radio signals intelligence would critically affect the outcome of the naval campaigns in the Pacific and Atlantic oceans.

Organizationally, the navies of the United States, Germany, Britain and Japan all chose to retain the techno-strategic paradigm of battleships and Mahanian control of the sea. There was evidence that this union was disintegrated by the conclusion of the First World War. During the interwar period, financial austerity and international arms regulation prevented navies from being able to build without constraint. Austerity focused naval priorities, and battleships were the main benefactor—this would prove to be the wrong choice. The Royal Navy emerged in the Second World War the most prepared to refight the First. Britain had doubled down on battleships to the exclusion of

455 Alan Beyerchen, "From Radio to Radar," in *Military Innovation in the Interwar Period*, eds. Williamson Murray and Allan Reed Millett (New York: Cambridge University Press, 1996), 270.

456 Beyerchen, *From Radio to Radar*, 273.

naval air power; they had also, misled themselves in their capacity to fight a renewed submarine campaign against their commerce.[457] However, when the war broke out, new techno-strategic possibilities were realized. What separated the competitors as each entered the war was partially a factor of how well each navy had retained options by spreading out naval developments during the interwar. Britain, the most traditionally minded of the four, was the least tolerant of organizational dissent. Having lost the majority of it aviators to the creation of the RAF, the Royal Navy failed to incentivize its Fleet Air Arm by limiting the command of carriers to general service officers, and forcing aviators to alternate their service between aviation and sea billets.[458] Japan, the United States, and Germany in contrast allowed a certain amount of advocacy by senior leaders, such as Yamamoto, Moffett, Dönitz, and Lockwood. However Germany, whose WWI experience should have provided the clearest lessons for the power of submarines, deserves criticism for failing to recognize its potentially broader role. Organizational diversity is difficult for militaries, and is exacerbated by both deliberate indoctrination and common professional education. However, organizational diversity may also have been the key element in retaining options.

Options were clearly needed by the Americans after the Japanese decisively resolved the question about whether an airplane could sink a battleship at Pearl Harbor on December 7, 1941. The attack on Battleship Row in Pearl Harbor was accomplished by a naval task force consisting of six carriers capable of launching 360 aircraft.[459] Battleships, and submarines, attended the task force but it was truly a carrier task force. The Japanese plan took full account of surprise attacking before a declaration of war and on a Sunday when they knew that the majority of military personnel would be relaxing, but the Americans were derelict to some degree as well by misinterpreting and not investigating what appeared to be a contingent of aircraft on radar.[460] The Japanese had benefited techno-strategically from their experience during their previous carrier-based

[457] Sumida, *The Royal Navy and Technological Change, 1815–1945*, 91.

[458] Till, *Adopting the Aircraft Carrier*, 207.

[459] John Keegan, *The Second World War* (New York: Penguin Books, 2005), 253.

[460] Keegan, *The Second World War*, 251–255.

campaigns in China, and their attack would decimate the U.S. Navy. Over the course of two assaults the battleships *Arizona, Oklahoma, California, West Virginia, Nevada, Tennessee, Maryland,* and *Pennsylvania* were all destroyed or disabled—all but the *Arizona* and *Oklahoma* returned to service later in the war.[461] Eleven other ships and 188 aircraft were also destroyed.[462] America declared war on Japan. The attack also, strengthened the United States's relationship and support for Britain, and by the 11th of December Germany and Italy would declare war on the United States. Fortunately, the United States had options. Neither carriers nor submarines had been docked at Pearl Harbor, and were therefore spared the Japanese onslaught. Both ship types had been task organized throughout the interwar within a battleship centric Mahanian concept of operations. However, the U.S. Navy even in the midst of the austere interwar, when pressures to assimilate along traditional lines were the highest had tolerated and promoted officers that thought slightly differently about naval operations. Those officers—Nimitz, King, Halsey, Spruance, and Lockwood—and the subordinates they had mentored now rose to the challenge and supplied the Navy with a new techno-strategic vision of offensive naval operations that entailed, not battleships, but submarines and carriers.

Although U.S. submarines operated to great effect in the Pacific throughout the duration of the Second World War, it would be the carrier battles that captured the headlines. The destruction of battleship row had exposed the U.S. Navy to the strides the Japanese had made in the techno-strategic paradigm of carrier-centric naval battle. Japan possessed an advantage in carrier strength of ten to three; furthermore, the Japanese Zero well was a well-tested aircraft and its pilots were both battle experienced and superbly trained.[463] However, the Japanese betrayed their further intentions in the Pacific by not attending to their communications security. American code breakers under the auspices of the "Magic" decryption program were able to determine that the Japanese's next target would by Port Moresby. The *Lexington* and the *Yorktown* were sent to oppose the

[461] Keegan, *The Second World War*, 255.

[462] Keegan, *The Second World War*, 255.

[463] Keegan, *The Second World War*, 268–269.

invasion.[464] The resulting Battle of Coral Sea from 4–8 May 1942 was indecisive tactically. Poor weather limited the aviators in the first days of the battle, but on 7 May in spite of the clouds the U.S. was able to sink the Japanese light carrier *Shoho* while losing the *Neosho* a refueling ship.[465] On the 8 May the two fleets would make contact again and in this exchange the U.S. came out behind. The aviators would attack the *Zuikaku* without effect and damage the carrier *Shokaku* to the point where it would need extensive repairs back in Japan, but the *Lexington* was so badly damaged that it would need to be abandoned and scuttled.[466] However, while the Japanese came out ahead in the battle tactically, the U.S. Navy had strategically checked the invasion of Port Moresby and Japanese expansion in the Pacific had been halted. Furthermore, the U.S. Navy gained some valuable carrier combat experience, which turned to their benefit in Midway the following month.

The Japanese plans for Midway were again betrayed by their poor radio procedures and the U.S. Navy's decryption efforts led by Captain Joseph Rochefort. However, in this case particular ingenuity was shown on the part of the Americans to clarify the intended target, which was coded by the Japanese as "AF."[467] To confirm that "AF" referred to Midway Island Rochefort's team sent a radio message *en clair* indicating that Midway's water distillation facility had malfunctioned.[468] The Japanese, as expected, intercepted the transmission and forwarded it using the notation "AF" which confirmed the U.S. Navy's hypothesis that "AF" referred to Midway.[469] Synthesizing the information allowed the cryptanalysts to accurately predict the dates for the upcoming Japanese offensives in the Aleutian Islands on June 3rd and at Midway on the June 4th. The Japanese, under the flag of Admiral Yamamoto, were marshaling a force of 67 ships that included four carriers and seven battleships. The U.S. Navy could only muster 26 ships. The odds are deceiving, though, because in terms of aircraft carriers the Japanese

[464] Keegan, *The Second World War*, 271–272.

[465] R. J. Overy, *Why the Allies Won*, 1 American ed. (New York: W.W. Norton, 1995), 35–36.

[466] Overy, *Why the Allies Won*, 36.

[467] Overy, *Why the Allies Won*, 38–39.

[468] Overy, *Why the Allies Won*, 39.

[469] Overy, *Why the Allies Won*, 39.

only had a one-ship and about a 100 plane advantage. Furthermore, the Japanese task force at Midway, in spite of all their carrier experience, centered itself around the battleship *Yamato*. In the *Yamato* class of battleship the continuing preference of the Japanese for bigger, faster, larger gunned and more heavily armored battleships is seen most clearly—for all their experience and success in using the revolutionary aircraft carrier, the Japanese still thought that control of the sea would be found in the evolutionary extremes of the battleship. Ironically by the end of the war both members of the *Yamato* class of battleship, the *Yamato* and *Musashi*, would be sunk by aircraft. After a diversionary attack on the Aleutians the Japanese planned to seize Midway using the carrier groups, and then to lay in wait for the American response.[470] When the Americans came the Japanese planned to destroy them using the strength of their battleships; a strength epitomized in the 62,000-ton behemoth *Yamato*. The U.S. Navy was disadvantaged numerically in both ships and planes, but in terms of information it had the advantage, and it was an advantage that would prove to be "the beginning of total failure."[471]

The overarching intent that governed the U.S. commanders at Midway was to use the airplanes provided by the carriers to attrite the Japanese forces while retaining the ability to break off the contact if necessary to preserve their forces. The land-based planes assigned to Midway were central to the plan and were tasked with reconnaissance to provide further intelligence on the Japanese exact locations. The land-based aircraft located the Japanese fleet and attacked in the morning on the 4 June, successfully sinking an oiler and convincing Admiral Nagumo that the islands' defenses must be subdued before the invasion could proceed.[472] Nagumo launched his planes to conduct a bombing attack against Midway Island, decimating the islands defenses. The remaining planes at Midway launched a counterattack prompting Nagumo to order his returning planes be rearmed with bombs for a second attack on the island; however, Nagumo was also

[470] Overy, *Why the Allies Won*, 37.

[471] Japanese Naval Minister Mitsumasa Yonai as quoted in: Overy, *Why the Allies Won*, 43.

[472] Keegan, *The Second World War*, 274.

receiving reports that a U.S. Navy ship had been spotted.[473] The potential of enemy ships prompted Nagumo to retract his order to rearm with bombs and instead to load torpedoes.[474] During the first wave of attacks the U.S. planes fared poorly, especially the torpedo planes whose low-and-slow approach made them vulnerable to both anti-aircraft fire and Japanese Zeros.[475] However, by moving to attack the low level torpedo planes the Zeros were not in position when the *Enterprise's* dive bombers arrived after struggling navigationally to find the enemy ships.[476] The 54 dive-bombers found their mark, within 10 minutes the *Kaga* and *Soryu* were sunk—their deck littered with aviation fuel and armament had magnified the effects of the bombardment.[477] The *Akagi* was also catastrophically hit, and was scuttled the next morning.[478] Later on June 5th, the *Enterprise's* dive bombers found their target again, sinking the fourth Japanese carrier *Hiryu.* The *Hiryu* managed to damage the *Yorktown* before its demise, and the *Yorktown* stalwart of the Battle of Coral Sea and Midway, was lost for good to a submarine attack three days later.[479]

Years of hard fighting remained, but the U.S. Navy had won a startling victory. Forced to abandon a battleship-centric concept of operations through their losses at Pearl Harbor, the U.S. Navy was able to rely on a reserve of experience in carrier operations that it had developed during the interwar. Furthermore, the early led in intelligence provided by "Magic" and enhanced by radar—essential to both the Battle of Coral Sea and Midway—would be retained. With the techno-strategic paradigm of carrier-centric operations established, the U.S. turned its manufacturing toward production. During 1943–44 the U.S. produced 90 carriers in contrast to the Japanese seven.[480] Furthermore, the interwar revulsion to submarine warfare was readily discarded after Pearl Harbor.

[473] Keegan, *The Second World War*, 274–275.

[474] Keegan, *The Second World War*, 274–275.

[475] Keegan, *The Second World War*, 275.

[476] Keegan, *The Second World War*, 608.

[477] Overy, *Why the Allies Won*, 41–42.

[478] Overy, *Why the Allies Won*, 42.

[479] Overy, *Why the Allies Won*, 42.

[480] Overy, *Why the Allies Won*, 43.

Submarines were dispatched to commence unrestricted submarine warfare against Japan on the same day as the attack on Pearl Harbor; Lockwood assumed command of the submarine effort in the Pacific in March of 1942.[481] Three-hundred submarines, over the course of 1,500 missions, sank 4,779,902 tons of merchant shipping and 540,192 tons of warships—a destruction that represented 54.6 percent of Japans' total tonnage.[482] While submarine warfare did not attract the attention that the major carrier battles did, their constant campaign of attrition wrecked Japan's ability to wage war. Also, Japan did not institute convoys until late in the war, and even then they generally sailed without the requisite protective naval and air escorts.[483] Oil supplies, the lifeblood of modern combat, were so diminished that, in the latter years of the war, conservation became so critical that the fleet could barely operate, and pilots received little flight time before they were expected to perform their duties.[484] While the U.S. was waging submarine war against Japan in the Pacific it was simultaneously defending against it in the Atlantic.

The allies narrowly avoided Japan's fate in the Battle for the Atlantic. Ultimately the intelligence capabilities that the allies obtained in the battle against submarines in the Atlantic would prove critical. Intelligence and effective escort—would, after many nerve wracking months, eventually be enough to staunch the Germans assault on merchant shipping. However, the difficulties the allies faced points toward the complexities of techno-strategic integration.

The Germans began their assault on commerce in the fall of 1939. Having, deliberately made the decision to use *Panzerschiffes* meant that when the assault on commerce commenced Dönitz had only 57 U-boats, and roughly half of those were of the smaller coastal design. The *Panzerschiffes* and the U-boats immediately began harassing British shipping, but since the U-boats were few in number and limited in range they were not yet a trans-oceanic menace. Nevertheless, 750,000 tons of shipping was sunk

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[481] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 195.

[482] Herwig, *Innovation Ignored*, 253.

[483] Overy, *Why the Allies Won*, 229.

[484] Overy, *Why the Allies Won*, 229.

between 1939 and the capture of French ports in June 1940.[485] However with the fall of France in June 1940, the Germans gained ports closer to Britain, and were able to patrol further into the Atlantic. To thwart the convoy system, which had helped alleviate merchant shipping attrition in the First World War, the German submarine arm began working in "wolf packs." "Wolf packs," a tactical concept of operations that used radio to coordinate the concentration of submarines against a convoy once it had been identified, were conceived by Dönitz during the interwar period. U-boats did not operate in packs, but they were able to coalesce in a swarm against merchant ships. These tactics were effective against merchant shipping in the larger expanses of ocean because by spreading the force out in a wide area the probability of locating a convoy was increased. Throughout 1941 the number of U-boats was increasing, and loses were minimal. By July 1942, U-boat numbers would reach 300, a number Dönitz's had proposed during interwar as ideal.[486] Between April and December of 1941 U-boats would sink 328 merchants carrying a combined 1,500,000 tons.[487] With America's entry into the war in 1942, new targets were available along the eastern seaboard and in the Gulf of Mexico. The United States's inexperience defending against submarines resulted in naïve mistakes, such as, sailing unescorted, not convoying, and using open radio communications.[488] The allied effort lost 2,600,000 tons of shipping between January and April of 1942; 1,200,000 tons off the eastern coast of the United States alone.[489] During a brief operational pause while Dönitz's U-boats were re-tasked by Hitler to Norway, the Americans started instituting more operational safeguards including the highly effective aerial escort.[490] In 1942 allied shipping losses reached their height. Central to the German superiority during this year was that they had the dual advantage in intelligence, their B-Dienst code breakers had cracked two successive British Naval codes (number 2 and 3), while their Triton cypher remained unbroken for the better part

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485 Keegan, *The Second World War*, 110.

486 Keegan, *The Second World War*, 106; Herwig, *Innovation Ignored*, 239.

487 Keegan, *The Second World War*, 112.

488 Overy, *Why the Allies Won*, 46.

489 Overy, *Why the Allies Won*, 47.

490 Overy, *Why the Allies Won*, 47.

of the year.[491] German operational security also increased. Dönitz started using the names of his commanders rather than boat numbers in his message traffic, and grid coordinates were further encoded into a unique alpha-numeric system.[492]

The allies were disadvantaged but not out. Realizing the need for accurate intelligence, both to avoid and attack the German U-boats, the British relayed on the Submarine Tracking Room, a fusion center for intelligence of all types pertaining to submarines.[493] Importantly the Tracking Room's efforts were enhanced by its staffing which included civilians from a variety of analytic backgrounds.[494] The tracking room collated, analyzed and disseminated intelligence gathered from observation, radio direction finding, and, when available, radio intercepts. Bletchley Park would succeed in breaking the German code by the end of 1942, and would not face a challenge nearly as difficult as Triton for the remainder of the war. While the tracking room's efforts were critical, they were part of a larger system. Air escorts were increasingly used resulting in a narrowing of the "wolf packs" area of operations. Furthermore, technical innovations continued to reinforce the development of anti-submarine tactics. Airplanes were equipped with Air to Surface Vessel radar, which could take them to within a mile of their target before the radar picture lost fidelity due to interference from the sea.[495] Recognizing the shortfall, airplanes were equipped with Leigh Lights, a powerful search light that allowed the airplane to maintain visual contact with an enemy submarine as they approached, an innovation that greatly limited German night-time attacks.[496] Forward-throwing depth charge launchers or "hedgehogs" were developed to avoid firing blind when asdic would lose fidelity during the final approach. Also, centimetric radar was made possible by the cavity magnetron, an innovation developed from the

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491 Overy, *Why the Allies Won*, 47.

492 David Kahn, *Seizing the Enigma: The Race to Break the German U-Boat Codes, 1939–1943* (Boston: Houghton Mifflin Co., 1991), 203–204.

493 Overy, *Why the Allies Won*, 48–49.

494 Overy, *Why the Allies Won*, 49.

495 Overy, *Why the Allies Won*, 50–51.

496 Overy, *Why the Allies Won*, 50–51.

integration of academic scientist from Birmingham University into the war effort.[497] Centimetric radar provided more resolution, and was immune to the German Metox, a device that warned crews when their U-boat was being detected.[498]

However the one critically effective tool—Very-Long-Range B24 Liberators—remained notably absent through 1942 U-boat onslaught. Again the inter-service rivalry between the independent RAF and the Royal Navy seems to have precluded clear thinking about how to most effectively techno-strategically integrate to win in the Battle of the Atlantic. During 1942 Britain lost an average of 500,000 tons a month. When the Liberators began closing what remained of the Atlantic gap in April and May of 1943 the effect on U-boat operations was almost immediate. In May 1943, Dönitz's force lost 43 U-boats a number that represented twofold what could be replaced.[499] The techno-strategic integration of Liberators equipped with radar and Leigh Lights, and better escort procedures enhanced through the regained information advantage made possible through Bletchley Park's efforts and fused through the Submarine Tracking Room in addition to the massive industrial capabilities of the United States to replace shipping loses proved insurmountable to the "wolf packs."

German "wolf pack" tactics at sea, like *Blitzkrieg* doctrine on land, relied heavily on radio communications. The Germans made extraordinary use of radio communications in the synchronization of their battle plans, but their assuredness that their radio encryption was secure was unfounded—the incentive of knowing the enemy's mind proved too powerful. Furthermore, the concentration of submarines in to a wolf pack required time and also ensured plentiful targets when the Liberators finally arrived in force in 1943. In this respect the American campaign of unrestricted warfare in the Pacific serves as a contrast. Lockwood's operationalization of submarine operations emphasized individual raiders—one of the main reasons why he dedicated his time to

[497] Overy, *Why the Allies Won*, 50–51.

[498] Overy, *Why the Allies Won*, 51.

[499] Keegan, *The Second World War*, 120.

selecting the right leaders for his subordinate commands.[500] By decentralizing to competent commanders who were responsible for operating within his intent within their areas of operations, Lockwood was able to minimize communications thus providing additional security and extending his effectiveness. It is reasonable to question whether this would have extended the operational effectiveness of Dönitz as well.

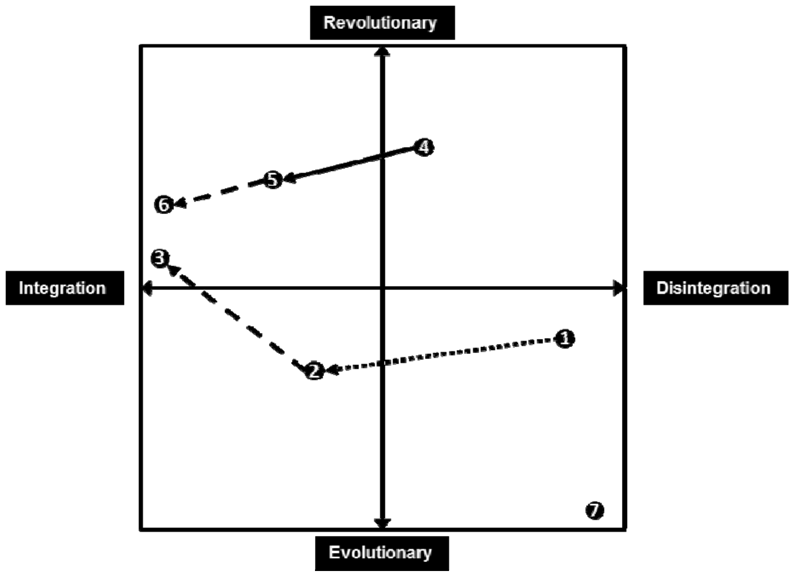

Figure 6. Figure showing the integration of battleships, submarines, and aircraft carriers from the interwar through WWII.

Battleships, submarines, and aircraft carriers represented difficulty techno-strategic choices during the interwar. Battleships, (Point 7) were revealed to be somewhat disintegrated by the conclusion of the First World War but were maintained and evolutionarily enhanced in spite of their poor wartime performance and the growing indication of their vulnerability to air attack. Both problems were discounted by the traditionalists at the top of the naval hierarchy.[501] The maintenance of an evolutionary, disintegrated technology in this case was the result of organizational preferences interfering with objective analysis and testing. Point 1 shows submarines' forcible disintegration which occurred as they were subjugated to a battleship support role that did

[500] Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 195.

[501] Richard Hough, *Death of the Battleship*, 1 American ed. (New York: Macmillan, 1963), 84–88.

not suit the inherent technological strengths of the form. Point 2 shows the wartime integration of submarines during the war by U.S. and Germany. The U.S. further integrated the submarine at (Point 3) by operating more decentralized and by better integration of radar. The U.S. and Britain also integrated against submarines, however, had either navy been willing to experiment more with submarines during the interwar it is reasonable to question whether the defeat of the "wolf pack" would have taken so long during the war. Aircraft carriers were the easiest to integrate from their fleet support role in the interwar represented at (Point 4) to their eventually ascendency in the naval hierarchy. The U.S. and Japan both integrated the carrier (Point 5), but in some ways the attack on Pearl Harbor forced the U.S. to fully integrated (Point 6) in a way that the Japanese never did. At Midway, Japan was still thinking within a Mahanian framework, while the U.S. had, by necessity, fully integrated carriers. Naval success in the Second World War was partly a factor of how fast a navy could move away from its perceptions of integration in the interwar period to effectiveness in combat. The U.S. was the most successful of the three not because its interwar techno-strategic position was closest the type of integration that could win naval battles but because they had maintained a diverse fleet, and had organizationally tolerated and promoted officers that thought outside of the organizational norms.

B. ARMIES

1. Achieving the Blitz

Mobility had returned to the battlefield by the conclusion of the First World War. However, the same pressures that influenced navies exerted themselves on armies. Financial constraints, war weariness, and the difficulty of inferring the right lessons from the experiences of the First World War affected the process of techno-strategic integration leading into the Second. Germany's use of mechanized *Panzer* forces under cover of closely coordinated supporting aircraft was successful in the opening years of the Second World War. The British showed successful use of tanks late in the First World War, but generally failed to capitalize on their early innovation in the Second, an astounding failure given that Germany was developing their doctrine while under the

severe military restrictions of the Versailles Treaty. Meanwhile the French, who had more tanks than Germany in 1940, failed to develop an adequate doctrinal concept that made the best use of the tanks speed, and instead focused on highly centralized deliberate operations.[502] The United States was, perhaps fortunately, prevented from attacking Germany head-on in 1942. Eisenhower may have wanted "to go to Europe and fight," but the U.S. Army was better served by gaining experience in North Africa—the exposure to German methods in that theater created a core of officers that would transform the army.[503] America's material production capacity uniquely suited its late adoption of wide-scale mechanization. The U.S. Army would so more than merely imitate German tactics they would fully mechanize the army.[504] The Soviet Union was also able to imitate German methods after being nearly defeated in 1941. Imitation then, can explain a good portion of the adoption of German mechanized methods during the war, but what explains the initial German success during the interwar period?

Limiting the discussion to Britain, France, and Germany is useful in this case because they represent the three main competitors of the western front—the birthplace of tanks during the First World War. Between these countries two macro factors are apparent related to the adoption of mechanized doctrine during the interwar. First, each army differed in its orientation to its strategic competition. Second, there was significant difference in the organizational tolerance for critical analysis and intellectual discourse. The identification of strategic competition is directly a function of civil-military relations. Politicians must define the strategic environment for their nation's militaries, and militaries must assist their political leaders in understanding the ramifications their decisions will have on national readiness. In Britain during the interwar the politicians, allowing for some outliers, did not correctly identify the growing threat Germany

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502 Williamson Murray, "Armored Warfare," in *Military Innovation in the Interwar Period*, eds. Williamson Murray and Allan Reed Millett (New York: Cambridge University Press, 1996), 32.

503 Eisenhower as quoted in: Rick Atkinson, *An Army at Dawn: The War in North Africa, 1942–1943*, 1st ed., Vol. 1 (New York: Henry Holt & Co., 2002), 11.

504 Overy, *Why the Allies Won*, 209.

represented to their security. The army also failed, within the context of limited funding and support, to adequately plan for contingencies that went beyond the relatively limited role the government defined for them.

The decidedly anti-war British attitude during the interwar was a direct result of their casualties during the First World War. A strategic approach developed, based largely on the result of Liddell Hart's analysis, which emphasized naval action with limited army involvement at the fringe.[505] The "limited liability" approach seemed to offer a way of avoiding large scale casualties in a continental conflict.[506] By 1937 this position was essentially made policy under the newly elected Prime Minister Neville Chamberlain, who also cut the Army's budget by £70 million.[507] In response to the Chief of the Imperial General Staff (CIGS) Lord Gort's assessment that the army was unprepared to fight first-class powers, the British government indicated their priorities for the army.[508] Safeguarding the homeland, protecting trade, and maintaining a colonial presence were all listed before any discussion of entering into a coalition for the defense of allies.[509] When the events in Czechoslovakia in the fall of 1938 finally started to force the issue of potential continental conflict it was too late.

Magnifying the lack of direction on the political front was an army that was thoroughly anti-intellectual and dominated by traditionalists.[510] Lord Milne, the first CIGS to seriously focus his staff's attention to studying the last war, did not take office until 1926. Milne was also, the only interwar CIGS to experiment with armor during maneuvers in 1927 and 1928.[511] Ironically, the Germans would learn more from these maneuvers, which highlighted some of the difficulties with logistics and communications support, than the British. Milne also organized the first staff study of the First World

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505 Murray, *Armored Warfare*, 9.

506 Murray, *Armored Warfare*, 9.

507 Murray, *Armored Warfare*, 10–11.

508 Murray, *Armored Warfare*, 10.

509 Murray, *Armored Warfare*, 10.

510 Murray, *Armored Warfare*, 22–23.

511 Murray, *Armored Warfare*, 20–28.

War's lessons in 1932; in hindsight this committee is more remarkable for its tardiness than its conclusions, which were critical of the army's wartime performance.[512] Milne's successor Montgomery-Massingberd, in a move echoing the Royal Navy's refusal to critically question its performance against submarines, redacted the report to limit its indictment of the army—the original was only seen by a few senior army leaders.[513]

The development of Close Air Support (CAS) was significantly hampered by the creation of an independent RAF. As already noted, the political position in Britain during the interwar was against employing the army in continental combat. This position, which seemingly implied that CAS would not be needed, bolstered the RAFs arguments on developing their force around a concept of strategic bombing rather than around supporting ground forces. Showing the same disregard for critical assessment as the Royal Navy and British Army, the RAF interpreted the history of CAS during the First World War as too costly for its effect.[514] Meanwhile, the analysis of the impact of Germany's bombing campaign on Britain were expounded upon in depth—a selection bias which supported the organizational predilection toward strategic bombing and away from CAS. Throughout the interwar period, the RAF was guided away from CAS so that by November 1939 it remained an option only in extremis.[515] Most egregious was the RAF's disregard for its own experience in its colonial "small war" actions. Indeed, the ability of the RAF to patrol and police large areas of Britain's colonial holdings was very beneficial to the service in terms of justifying its independence.[516] In these actions experience was gained employing air power in conjunction with ground forces; however, the exposure of these to a larger contingent of the force was low. The thoroughly anti-intellectual environment of the British services during the interwar period prevented the widespread dissemination of professional articles which could have increased familiarity.

512 Murray, *Armored Warfare*, 20.

513 Murray, *Armored Warfare*, 20.

514 Richard R. Muller, "Close Air Support," in *Military Innovation in the Interwar Period*, eds. Williamson Murray and Allan Reed Millett (Cambridge; New York: Cambridge University Press, 1996), 165.

515 Muller, *Close Air Support*, 165–166.

516 Muller, *Close Air Support*, 170.

Finally, there was a lack of imagination to reflect on the colonial experience and extrapolate a larger endeavor. At the other end of the spectrum in both areas of identification of the competitive environment and encouragement of critical analysis was Germany.

Germany's public remained enamored of its military in a way that Britain's did not. Furthermore, Hitler's rise to power in 1933 removed mast financial restrictions on rearmament. The conditions of austerity the German army faced by the stipulations of the Versailles Treaty, which prevented the possession of tanks and restricted the size of the army to 100,000, may have actually benefited the conditions for innovation. Specifically, General Hans von Seeckt, during his duties as the chief of the general staff was able to select 4,000 officers for retention out of 15,000 available.[517] This winnowing heavily favored officers that had previously served within the German General Staff, resulting in an officer corps of considerable intellectual talent, as selection for the general staff was based on merit, not predominated by traditionalists.[518] Seeckt had the right intellectual foundation in place, and he subsequently set their minds to examining the lessons of the First World War. Four hundred officers, representing 10 percent of the active officer force, participated in 57 committees and their finding were published in 1921 and 1923 as Army Regulation 487, "Leadership and Battle with Combined Arms."[519] German doctrinal development, emphasizing maneuver, offense, decentralization, and initiative, was developed in light of these publications and before the re-emergence of tanks.[520] Seeckt established the same intellectual foundation for the development and operationalization of CAS. The *Gruppe Luftstreitktäfte* was created in the 1920s to systematically study the lessons of the First World War.[521] Most importantly, the German military was not encouraged to think uniformly. Separate

[517] Murray, *Armored Warfare*, 36.

[518] Murray, *Armored Warfare*, 36.

[519] Murray, *Armored Warfare*, 37.

[520] Murray, *Armored Warfare*, 37–38.

[521] Muller, *Close Air Support*, 156.

groups arrived at different conclusions and all were equally debated.[522] The same culture of intellectualism and experimentation prompted German officers to study and draw conclusions from the limited British armored experiments carried out under Milne, and to send some of their officers to Russia to work with Soviet tankers and airmen.[523] When Germany was able, under Hitler, to resume militarization their efforts were guided by the conclusions drawn from these interactions. Doctrine developed through rigorous analysis preceded the massive rearmament that Hitler pursued. The doctrinal concepts of operations guided the development of technology. Furthermore, early combat experience could be compared against the expectations inherent in their doctrinal foundation. Experience could then be rapidly assimilated into doctrin to shape a cohesive system of mechanized maneuver warfare—Blitzkrieg. French interwar development represented the metaphorical as well as the actual middle ground.

France's recognized early that Germany was the likely threat. However, their analysis, which reflected their failed 1917 campaigns, mistakenly interpreted the relationship of offense to defense. Therefore, the French molded their army to best refight the First World War against the technology that had existed, not as it would exist in the Second. The Maginot Line epitomized the misreading of the techno-strategic situation. French doctrine, stressing the power of artillery fires tied into a defensive belt, was methodical in its application, unlike Germany, which was stressing individual initiative and decentralized execution. Later in the 1930s it became increasingly apparent to some of the lower echelons that mechanized forces presented new operational possibilities. But by 1935 the Commander in Chief, General Gamelin, had instituted a policy that centralized the authority for all publications to the high command, effectively eliminating the freedom to explore new doctrinal avenues.[524]

The French Air Force was no better off. France's numerous planes from the 1920s were retained into the 1930s.[525] As the growing threat from Germany mounted the

[522] Muller, *Close Air Support*, 157.

[523] Murray, *Armored Warfare*, 39; Muller, *Close Air Support*, 156.

[524] Murray, *Armored Warfare*, 34.

[525] Alistair Horne, *To Lose a Battle; France 1940*, 1st ed. (Boston: Little, Brown, 1969), 82.

French tried to reenergize their air force, but these efforts were stymied by ineffectual civilian leadership.[526] The French program to rebuild it air force proceeded slowly in 1939 France was manufacturing 600 planes a year in contrast to the nearly 3,000 being produced in Germany.[527] The gap in manufacturing and was further exacerbated by a lack of a concept of operations that conjoined CAS with ground maneuver. France's neglect of airpower during the interwar period created a capabilities gap, and their rapid capitulation prevented them from potentially making up for their deficiencies through late modernization once the war began

The German techno-strategic integration of it planes and tanks in a concept of operations emphasizing maneuver, offense, and decentralized subordinate initiative laid the groundwork for early German successes. However, the details were not fully worked out. Further innovation in the techno-strategic integration of aerially supported mechanized combat continued, and may have even accelerated through the early experiences in the Spanish Civil War and in Poland. Through these experiences the army was able to capitalize on its broad intellectual underpinning, to further adapt its burgeoning doctrine while fighting. By the dramatic push through the Ardennes in May 1940 the concept had advanced significantly. While the forces in France were defeated so swiftly that they were unable to benefit from imitation, the United States and the Soviet Union both benefited from the exposure to the German's advantages and were able to build up and surpass the original innovator. Stalin himself noted in November 1941 that "In modern warfare it is very difficult to fight without tanks and without adequate protection from the air."[528] The soviets had a decisive numerical advantage over the Germans in 1941, but a poor concept of operations.[529] After the defeat the Soviet Union would turn its attention to the manufacture of both armor and airplanes in 1942, and would adjust their concept of operations significantly.[530] The United States

[526] Horne, *To Lose a Battle; France 1940*, 82–83.

[527] Horne, *To Lose a Battle; France 1940*, 83.

[528] Overy, *Why the Allies Won*, 209–210.

[529] Overy, *Why the Allies Won*, 211.

[530] Overy, *Why the Allies Won*, 211.

too was able, at a distance, to observe and innovate. During the 1930s the U.S. Army had one Brigade of mechanized Cavalry consisting of 224 light tanks.[531] Two divisions were established in an independent armored force in 1940 and another three divisions were created in 1941.[532] America further benefited because it made the decision to fully motorize its entire supporting infantry, artillery, and logistical apparatuses. Whereas a Panzer Division consisted of 328 supported by 97 other vehicles, an American Division had 375 tanks supported by 759 other vehicles.[533] Material production in and of itself however was not solely responsible for the shifting for balance of fortunes. Allied forces also further expanded the new techno-strategic paradigm into a broader strategic concept that included the Germans. The Panzer groups were indeed formidable, but they represented a small portion of the force.

C. AIR FORCES

1. Strategic Bombing and its Defense

As mentioned earlier, nations faced interesting questions in the techno-strategic integration of airpower during the interwar period. Air power emerged from the First World War with seemingly endless potential. Having performed a variety of missions, it was unclear where airpower would find the most utility in future wars. In the aftermath of the First World War, air advocates such as Douhet, Mitchell, and Trenchard, offered a techno-strategic concept of operations that seemed to offer decisive results with minimal casualties. By targeting the enemy's centers of production, economic resources, and even the population itself, the effects of bombing on civilian morale promised to bring war to a swift conclusion. After all, while other things may be in doubt, there was no doubting that "the bomber will always get through."[534] Although Britain had been bombed during the First World War, their experience seemed to disprove a number of the claims of bombing advocates. During the Second World War, strategic bombing survived in spite

[531] Overy, *Why the Allies Won*, 223.

[532] Overy, *Why the Allies Won*, 223.

[533] Overy, *Why the Allies Won*, 224.

[534] Williamson Murray, "Strategic Bombing," in *Military Innovation in the Interwar Period*, eds. Williamson Murray and Allan Reed Millett (New York: Cambridge University Press, 1996), 102.

of its underwhelming record of effectiveness. In Germany bombing, by and large, was effective not for the effects it had on the morale of the civilian population but because combating it pulled the *Luftwaffe* effort away from supporting the troops. By the end of the war strategic bombing had render the Germany manufacturing base impotent, but the allied advances by that point indicate that the war in Europe was won before the bombing effort had accomplished its objective. Japan too was on the brink well before the bombing campaign achieved its effect. However, the addition of the atomic bomb to the bomber arsenal seemed to once again revive the notion that you could bomb an enemy into capitulation using air power alone. Although the use of the bomb on Japan was questionable even at the time, it may have made strategic bombing techno-strategically viable, but at the cost of turning war into genocide. Before the atomic bomb became a reality though a host of supporting technologies were developed and introduced to assist navigation, accuracy, and defense. Although the effectiveness of bombing is questionable it was through these additions that the bombing paradigm came into its own as a form of warfare. Strategic bombing became a tool of total war.

The United States and Britain were the most taken with the concept of strategic bombing. Germany, on the other hand, developed its capacity for bombing within a more inclusive aerial doctrine and not in opposition to other forms of air combat. Geographic position, financial commitment, and air forces' desire for organizational differentiation contributed to pursuing strategic bombing during the interwar. During the course of the war scientific advances and production capability took the idea and transformed it to reality. The idea that a nation could launch an air attack presented new strategic vulnerabilities to the United States and Britain. The narrow seas and the oceans could no longer serve as a final barrier against direct attack.[535] Germany's central location on the other hand limited their conception of strategic bombing within a more local framework—of the three powers discussed they alone would not develop a four engine bomber.[536]

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[535] Murray, *Strategic Bombing*, 102.

[536] Murray, *Strategic Bombing*, 109.

Financial constraint and a political climate of war aversion presented challenges to militaries in the interwar. In Britain these challenges were increased to some degree by the creation of an independent RAF. The RAF needed to compete against claims from the army that air was best used to support ground troops, and claims from the navy that air was best used in maritime operations.[537] The RAF, playing to some degree on the fear that was generated politically by the overselling of the threat, embraced the one mission that set them apart—strategic bombing.[538] The chief of staff of the RAF in the interwar period, Hugh Trenchard, was instrumental in advocating this mission, thus preserving the RAF as an independent force. The political situation in Britain made strategic bombing an easy sell. Bombing fit nicely into Britain's overall strategy of avoiding "continental commitment" while still maintaining the ability to apply military pressure. Bur it was a house of cards. In the struggle for organizational autonomy the RAF sought and promoted historical examples that supported the concept of strategic bombing while glossing over other evidence.[539] Bombing strategy, and it promises, had eclipsed technology. Bombers had trouble navigating to target, trouble hitting targets, inadequate capacity, and limited range.[540] Furthermore, the RAF had advanced a strategy of knocking out vital economic centers, but had done little to analyze what and where these targets were.[541] Finally, the widespread belief that bombers would and could get to their target in spite of air defenses limited the development of both the strategy and the technology necessary to achieve air superiority before starting a bombing campaign. This last misunderstanding persisted to the end of 1943 in spite of the widespread losses suffered by British Bomber Command and the U.S. 8th Air Force. Contributing to the disintegration between technology and strategy was Britain's inadequate investment in the aircraft industry during the interwar.[542] The Chamberlain government had bought

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537 Murray, *Strategic Bombing*, 104.

538 Murray, *Strategic Bombing*, 104.

539 Murray, *Strategic Bombing*, 117.

540 Overy, *Why the Allies Won*, 107.

541 Overy, *Why the Allies Won*, 106; Murray, *Strategic Bombing*, 119.

542 Murray, *Strategic Bombing*, 103.

into the strategy, but their funding restrictions prevented it from being realized. Both sides of the civil-military equation are at fault. The RAF had oversold the capability, and the government failed to ask the hard questions to accurately assess the reality.

In America the same struggle for autonomy manifested itself, but in this case the army's aerial contingent argued for strategic bombing as a way to achieve independence not to preserve it.[543] Initially air power theory in the U.S. was balanced between the roles experienced in the First World War. Billy Mitchell advocated a force consisting of fighters, bombers, and observation aircraft.[544] Furthermore, American debates advanced by Mitchell and de Seversky, considered that bombing would be best accomplished after control of the air was established.[545] The Air Corps thus experimented with protecting its bombers with long-range escorts throughout the 1920s and 1930s, but the technological limitations at the time seemed to prevent the development of an acceptable escort that had the range to accompany bombers yet possessed the maneuverability to thwart enemy fighters.[546] Over time the seemingly irresistible idea that the enemy could be bombed into submission rather than fought took hold of the Air Corps' imagination. The transformation to a bomber oriented force was completed when the difficulties inherent in dealing with enemy interceptors was "solved" by the doctrinal development of flying in dense formations of defensively armored bombers. The assumption underpinning this doctrinal solution was that bombers could defend themselves—reality would be slow to change this assumption.[547] America however, unlike Britain, complemented its strategic formulations with technological advances. The expanse of America fueled advancements by civil aviation. The U.S. government heavily supported the aviation industry which

[543] Murray, *Strategic Bombing*, 122.

[544] Murray, *Strategic Bombing*, 123.

[545] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 334.

[546] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 334–335.

[547] Murray, *Strategic Bombing*, 125.

made advances in all areas of aircraft performance and navigation during the interwar period, and established a manufacturing base that could turn its attention toward production of military aircraft when the situation demanded it.[548]

Germany's view of air power remained more holistic then either the United States or Britain. Geographically, Germany's position as a contiguous land mass may have limited their thinking of air power as a new strategic frontier; instead they saw air power in terms of its ability to operationally extend combat power in conjunction with the conventional land and sea forces.[549] Although Seeckt supported and commissioned a thorough investigation of the uses of air forces in the First World War, other conditions in interwar Germany limited overall the development of strategic bombing. Significantly, Germany was prevented from having an air force or even a civil airline industry by the Treaty of Versailles; by 1932 the German aircraft industry would be constituted by a meager 4,000 workers and was almost devoid of research and development capabilities.[550] The lack of available airplanes also directly impacted the ability of the German military to conceive of a broader strategic role an air force could potentially play. When Hitler came into power in 1933 he immediately began growing the entire military. The Luftwaffe under Herman Göring began its expansion, but strategic bombing never emerged as a separate from the overarching doctrine of supporting land operations. The long-term impact of the limitations on the Germans' air industry also continued to impact their development of a long range four engine bomber, prototypes were developed but a solution to the power plant problems were never fully overcome.[551] In contrast Germany held an early advantage in supporting navigation and targeting technology, but this lead would eventually be overcome during the war.[552] Finally German air forces gained experience in modern aerial combat during the Spanish Civil War from 1936 to 1939. Britain and the United States went to war with some unrealistic

[548] Murray, *Strategic Bombing*, 107–108.

[549] Murray, *Strategic Bombing*, 108–109.

[550] Murray, *Strategic Bombing*, 111.

[551] Murray, *Strategic Bombing*, 132.

[552] Murray, *Strategic Bombing*, 134.

expectations regarding the implementation of a techno-strategic concept of strategic bombing, and a neglected doctrine of CAS. While the German Condor Legion had made great strides in solving some of the problems between air-to-ground integration, and also through its experience with some of the operational difficulties in navigation and targeting a realistic conception of the efficacy of bombing.[553]

Bombing at the start of the war was techno-strategically disintegrated; the strategy was unsupportable by the technology. However, integration improved during the war. Churchill, an active supporter of air power during the interwar, almost immediately committed the RAF in a bombing campaign against Germany upon his appointment as Prime Minister. Given the British defeat in Norway, the German onslaught in France, and the poor state of the British Army as a result of the interwar strategy of avoiding continental conflict, there was little else Churchill could do. Bombing represented the only offensive option; it was an option based not on real capability but rather on exaggeration. The initial attacks in May of 1940 quickly showed how hollow the concept was. Early daytime losses necessitated night-time attacks, which magnified all of the problems in navigation and accuracy. The techno-strategic choices made during the interwar period limited the flexibility of Britain’s response. The Germans, however, did not develop a true strategic bombing force. Rather their concept of airpower was more integrated in support of its army. The bomber that proved so effective in a CAS role was a single engine dive bomber the JU 87. Dive bombing greatly increased accuracy, but when dive bombing became a specification for a four engine variant the problems proved insurmountable and prevented alternative concepts.[554] The Germans did have capable medium bombers, and their doctrine called for the employment of escort fighters. However, here again the German air armada showed limitations inherent by its being designed for an operational support role. The medium bombers did not have the capacity or range of a heavy “strategic” bomber, and the escort fighters suffered seriously from

[553] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 101; Murray, *Strategic Bombing*, 134.

[554] Overy, *Why the Allies Won*, 104; Murray, *Strategic Bombing*, 132.

fuel constraints—the Messerschmitt 109's range was 125 miles.[555] Numerically however, Germany had the advantage and the Germans had also made progress in solving some of the difficulties in navigation and target identification through the use of radio beacons, and Lorenz beams.[556]

The British countered with superior intelligence, and information management. These advantages and the absolutely heroic performance of the RAF' Fighter Command would prove to be decisive in the Battle of Britain. British decryption efforts were successful in May 1940 of cracking another Enigma cypher.[557] The intercepts would play a role in revealing how the Germans were using radio navigation and targeting aids, which were subsequently jammed or manipulated to provide false information to the German aircrews.[558] Britain furthermore, had not neglected its defense. Revolutionary radar technology was deployed across the coast line in a series of 21 long range stations and 30 low level stations known as Chain Home and Chain Home Low respectively.[559] The radar network was connected by telephone line to Fighter Command, which also received additional information regarding enemy positions from the civilian Observer Corps.[560] The Observer Corps proved to be the key element in the Battle of Britain. The information from all sources was plotted and disseminated by Fighter Command, and enabled them to issue warnings and scramble fighter intercepts in a timely fashion. Through the superior intelligence and information management made possible by British's techno-strategic integration of radar into a system of anti-aircraft defense the numeric discrepancy in the Battle of Britain may have been overcome.

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[555] Keegan, *The Second World War*, 92.

[556] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 134.

[557] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 131.

[558] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 134.

[559] O'Connell, *Of Arms and Men: A History of War, Weapons, and Aggression*, 278.

[560] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 132.

Interestingly, Churchill and Britain in general did not evaluate their own experience on the receiving end of a bombing campaign. Bombing had not seriously impacted production, and may have actually increased British commitment.[561] The analysis had been done on Bomber Command's effectiveness however. The results were staggering in their indication that bombers simply could not hit targets—in good condition one bomber in three could get to within five miles in poor conditions that result fell to one in 15.[562] Yet Churchill, still unable to open a second front in Europe in 1942, had offered a renewed bombing campaign against Germany as conciliation to Stalin when pressed to relieve the pressure the Soviet Union was facing from a renewed German onslaught.[563] Stalin had no choice but to accept. The Americans had also, joined the fray. Roosevelt in contrast to his position during the interwar proved just as enamored as Churchill of the power of the strategic bomber, and had ordered the production of 500 bombers a month in May of 1941.[564] German air defenses also incorporated radar, intercept fighters, and the formidable 88—an air-defense artillery piece that duly served as an anti-tank gun—by 1941 British losses were reaching replacement thresholds.[565] In 1942 Arthur Harris assumed command of the British bombing campaign, and he would preside over the command as it transitioned to an area bombing offensive directly targeting the civil population's morale.[566] When faced with the operational reality that the bombers could not hit their intended targets, the Churchill government based on recommendations form Lord Trenchard adjusted the strategy to target what they could hit. Broadly this included the entire industrial infrastructure to include workers housing.[567] Moral questions aside, it was a strategic shift, and soon technology would emerge that complimented it. The four-engine Lancaster with its greatly improved

[561] Overy, *Why the Allies Won*, 109.

[562] Overy, *Why the Allies Won*, 111.

[563] Overy, *Why the Allies Won*, 101–104.

[564] Overy, *Why the Allies Won*, 109.

[565] Overy, *Why the Allies Won*, 111–112.

[566] Overy, *Why the Allies Won*, 113.

[567] Overy, *Why the Allies Won*, 113.

capacity, and “Gee,” a radio navigation and targeting system, both became increasingly available.[568] The American 8th Air Force would launch its first attacks in August of the same year.

The Americans were committed to precision daylight bombing; a technique that they thought would be possible with their Norden bomb-sight. As the number of raids increased the amount of men and material Germany committed to air-defense increased. In 1943, when Churchill and Roosevelt prioritized the bombing mission, the inevitable culmination had begun. The Germans were able to defeat Gee, and German fighters were increasingly equipped with radar to assist finding their targets at night. The British responded with two new navigational and targeting aids Oboe and H_2S. H_2S was superior because it eliminated the necessity for ground control stations and soon pathfinder aircraft equipped with H_2S would illuminate the target area for the follow on bombing. The final development in the back-and-forth radar fight was the development of chaff code, named “Window.” Chaff—strips of metal flung from a flying plane—would blinded German radar by presenting overwhelming amounts of false information. The American practice of flying in dense self-protective formations was increasingly exposed as faulty. In one raid launched against the Schweinfurt ball-bearing factory in August of 1943 the Americans lost 36 out of 229 bombers.[569] However, the advances in radar targeting and radar jamming were paying off by the late summer of 1943. In July, Hamburg would be bombed relentlessly with a mixture of high-explosive and incendiaries, the result was a fire maelstrom that killed 30,000 and left one million homeless, and it was not the last.[570] The final obstacle to techno-strategic integration—a suitable long range escort fighter—was addressed by introduction of the P-51 Mustang in March of 1944.[571] Capable of escorting bombers all the way to Berlin and back, the P-51 made possible a wholesale bombing onslaught by January 1945 Albert Speer informed

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[568] Overy, *Why the Allies Won*, 113–114.

[569] Keegan, *The Second World War*, 425–426.

[570] Keegan, *The Second World War*, 426–427; Overy, *Why the Allies Won*, 119–120.

[571] Overy, *Why the Allies Won*, 123.

Hitler that "The war is over in the area of heavy industry and armaments."[572] However, by this point in 1945 Germany had really already lost the war due to losses on the ground and at sea. Strategic bombings path to integration cost 600,000 German civilian dead and 800,000 wounded.[573] Later in the year, and in another theater, strategic bombing would take on a whole new dimension in its ability to impact the enemy's morale—the United States was nearing completion of the Atomic Bomb.

2. Atomic Bombs

Although much of the science underpinning the atomic bomb preceded WWII it is convenient, to start the timeline of the Manhattan Project in the summer of 1939. During the summer of 1939 Léo Szilárd and Eugene Wigner approached Albert Einstein—the latter's recommendation was considered essential if the project were to be taken seriously—and drafted a letter to President Roosevelt outlining the potential of nuclear physics to deliver a devastating new weapon.[574] The seed that would become the Manhattan Project had been planted. Meanwhile the war in Europe continued, with America anxiously watching from a position of relative safety. Interestingly Roosevelt approved the atomic program in October 1941—two months before the fateful bombing at Pearl Harbor. Shortly thereafter, at universities across the countryside, America's leading physicists began meeting to make a determination regarding how to precede both theoretically and operationally. Given that the enrichment of Uranium and production of Plutonium—critical components of a bomb—was cutting edge physics, and that literally the best minds from across the country were working on the problems it is not surprising that a consensus was not fully reached. However, there was agreement that the creation of an atomic bomb was possible. Furthermore, since the scientists felt as though they were racing against Germany; and, that therefore, there was no time to try one strategy at a time the scientist eventually recommended five different methods for uranium enrichment and plutonium production be pursued simultaneously.

572 As Quoted in: Overy, *Why the Allies Won*, 125.

573 Keegan, *The Second World War*, 433.

574 Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986), 302–307.

These recommendations were accepted and in June of 1942 Roosevelt approved the budget and basic course of action put forward to develop a nuclear bomb.[575] In the fall of 1942 Colonel Leslie Groves was selected to lead the Manhattan Engineering District, soon to be known simply as the Manhattan Project. Groves an engineer by trade had recently completed the construction of the pentagon, and been promoted to brigadier general. Groves would be characterized by his biographer Robert S. Norris as "indispensable":

> Without Groves's vision, drive, and administrative ability, it is highly unlikely that the atomic bomb would have been completed when it was. The Manhattan Project did not just happen. It was put together and run in a certain way: Groves's way. He is a classic case of an individual making a difference. [576]

Groves, perhaps understanding both the scientific need for collaboration and the military need for secrecy directed that an offsite facility be procured for the scientist. After some initial scouting, Dr. Robert Oppenheimer suggested the boy's school known as Los Alamos. The site was accepted in November 1942.[577] Even at this early stage Oppenheimer's influence on Groves and the project in general is apparent. This influence would be critical over the next year as Oppenheimer essentially went on a recruiting tour throughout the country's top physics departments to staff the compound of Los Alamos with talent. The free exchange of ideas, which was critical to the scientist and considered dangerous by Groves was eventually accomplished by the removal of the scientist to an offsite location in the middle of the desert. This was perhaps Groves's boldest and best move. At the facility itself the scientist organized themselves functionally by discipline, a style that was comfortable to them as many had been recruited out of university departments.[578] Also, due to the offsite location the administrative and logistical support was supplied by the military.

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575 Rhodes, *The Making of the Atomic Bomb*, Chapter 13.

576 Robert S. Norris, *Racing for the Bomb: General Leslie R. Groves, the Manhattan Project's Indispensable Man*, 1st ed. (South Royalton, Vt.: Steerforth Press, 2002), x.

577 Rhodes, *The Making of the Atomic Bomb*, 450.

578 Norris, *Racing for the Bomb: General Leslie R. Groves, the Manhattan Project's Indispensable Man*, 247.

Furthermore, there was international collaboration among some of the allies specifically England and Canada. Edward Condon, who had been selected by Oppenheimer to be the associate director at Los Alamos stated that the mission "is to produce a *practical military weapon* in the form of a bomb in which the energy is released by a fast neutron chain reaction in one or more of the materials known to show nuclear fission."[579] Inherent in the mission is the specification of two outputs: fissionable material, and a vessel capable of containing the material and initiating the chain reaction. Both outputs were on the cutting edge of theoretical physics and engineering, but at least there was general agreement about what had to be done. The method to produce fissionable material either in the form of weapons grade uranium, or plutonium had been reasonably solved. However, since the requirements for a bomb were different than what was needed in a laboratory specifically in terms of quality and quantity there was still some uncertainty exactly how to proceed. Given that "the unit of measurement for wasted hours was…[friendly] lives," Groves and the scientists decided to industrialize the manufacturing process of fissionable material using all known techniques simultaneously a move only possible by the high level of support the project had both politically and financially.[580]

Over the next two years two problems were tackled. First the project needed to refine the process of uranium enrichment and plutonium production; secondly, the final design of the bomb had to be worked out. Both problems were solved simultaneously and culminated in the Trinity test on 16 July 1945. Following the successful test bomb production began. Two bombs were readied for delivery on Japan in August of 1945 resulting in the devastation of Hiroshima and Nagasaki. Soon thereafter, the Japanese surrendered. "Before the end of the war, approximately 600,000 people had worked on the project, which at its peak employed more than 160,000."[581] Although the Manhattan Project is primarily remembered as a feat of science and military collaboration, the Los Alamos site only accounts for 10,000 of the total number involved in the project, and that

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[579] Rhodes, *The Making of the Atomic Bomb*, 460–461.

[580] Rhodes, *The Making of the Atomic Bomb*, 459.

[581] Norris, *Racing for the Bomb: General Leslie R. Groves, the Manhattan Project's Indispensable Man*, 227.

number, accounts for all the people at Los Alamos to include wives and children.[582] Where was everyone else? The majority were involved in construction. Sites across the country had to be constructed before any manufacturing work could be accomplished. However, it was the theoretical work at Los Alamos that was absolutely cutting edge. The Manhattan Project represented a nearly perfect union of civil-military effort. The full weight on America's industrial prowess, material wealth, and most importantly scientific talent was brought to bear for the purpose of developing an atomic weapon.

The German atomic project in contrast was ultimately unable to produce. The German scientists were making parallel discoveries throughout the war, but in the end it was the allied effort that yielded a bomb. Germany had a commanding lead in the field of physics. Otto Hahn whose original work in uranium fission in 1939 was the foundation for nuclear weapons projects in both countries was German.[583] Indeed, the German scientists from the Nazi atomic bomb project were in captivity when the U.S. employed the first atomic bombs in Japan—having failed in their own attempt they were unwilling to concede that other scientist had solved the problems.[584] German scientist had made good progress, up until 1942 their advancements were roughly parallel with the allies, however, the German effort never achieved the level of governmental support that the Manhattan project had.[585] The German project in contrast to the Americans suffered from the lack of scientific direction and management. The military ceased work on the project in 1942, and the scientist were brought under control of the Education Ministry.[586] The German scientists, informally led by Werner Heisenberg, a theoretical

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582 Norris, *Racing for the Bomb: General Leslie R. Groves, the Manhattan Project's Indispensable Man*, 247.

583 Overy, *Why the Allies Won*, 235.

584 David John Cawdell Irving, *The German Atomic Bomb; the History of Nuclear Research in Nazi Germany* (New York: Simon and Schuster, 1967), 11–13.

585 Overy, *Why the Allies Won*, 237; Irving, *The German Atomic Bomb; the History of Nuclear Research in Nazi Germany*, 303.

586 Overy, *Why the Allies Won*, 236.

physicist, were more content theorizing rather than operationalizing the science through industrial and engineering advancements.[587] Without a Groves figure the scientists were not pushed by the Nazi government towards production.

German scientists were also at work in the cutting edge science of rocketry. This field, unlike the atomic project, had the full support the German government. By 1932 the German Army had a secret rocket laboratory and a young pioneer in the field, Wernher Freiherr Von Braun, was working toward the first generation of German military rockets.[588] This program would grow, and would be the foundation of the huge growth in missiles during the Cold War. During the Second World War German made revolutionary progress toward the creation of a working missile. The A4, later the V2, would be ready by June 1942, but would still be suffering from some problems in its guidance system.[589] As the war continued the pressure from Hitler to devise new *Wonderwaffe* for retaliatory purposes increased. In 1943 the *Luftwaffe* had developed what would become the V1, a similar device to the A4, but with a jet based propulsion system—the V1 would become the basis for cruise missiles following the war.[590] The innovation that was taking place during war was extraordinary, but was it effort well spent? Hitler increasingly looked to technology as a means to winning the war, but the V1 and V2 were still too revolutionary to be integrated decisively into a war winning strategy. The time, money and effort spent on these projects could have been more effectively used to produce more of the technology being consumed in the everyday fighting. Richard Overy for example points out that for the costs of the V-Weapons program an additional 24,000 planes could have been produced, and there is little doubt that the planes would have had a large impact than the rockets.[591]

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[587] Irving, *The German Atomic Bomb; the History of Nuclear Research in Nazi Germany*, 299.

[588] Overy, *Why the Allies Won*, 238.

[589] Dennis Piszkiewicz, *The Nazi Rocketeers: Dreams of Space and Crimes of War* (Westport, Conn.: Praeger, 1995), 72–73.

[590] Overy, *Why the Allies Won*, 239.

[591] Overy, *Why the Allies Won*, 240.

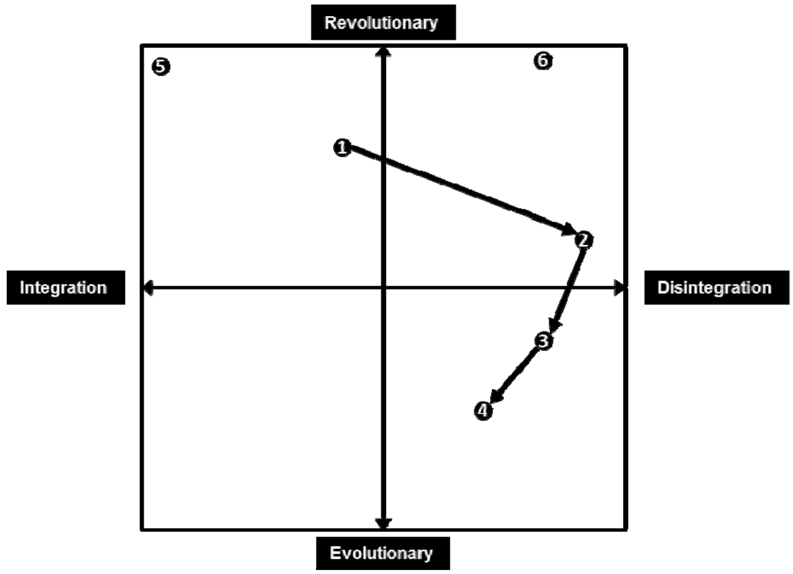

Figure 7. Figure showing the U.S. and British integration of strategic bombing (Points 1–4), The Atomic Bomb (Point 5) and the German *Wonderwaffe* (Point 6)

Point 1 shows the perceived position of strategic bombing during the interwar. Airpower advocates claimed more for the strategy than was warranted because it promoted organizational autonomy. The technology was shown to be disintegrated from the strategy during its initial employment by Britain forcing night time attacks which increased the problems of navigation and targeting as shown in point 2. With support from civilian leaders the strategy is transformed. Bombers unable to hit precision targets are refocused on area targets, which were broadly enemy urban areas. While this made the strategy more destructive it did not make it more effective resulting in further disintegration as shown in point 3. Point 4 represent the development and use of radar navigation and countermeasure, and escort fighters both of which further enhanced the evolution of the strategy but did not make inroads to effective integration. Nuclear weapons, a separate development from air power, are represented at point 5. Point 6 represents the German V-Program. The technology was very revolutionary, but it was unable to be integrated because it had not achieved a sufficient level of viability. The continued emphasis on the programs siphoned money, material, and labor away from other integrated weapon systems that could have been more impactful on the outcome of the war.

D. SUMMARY

The First World War presented difficult techno-strategic questions. The scale of the conflict ensured wide exposure to new technologies, but nations faced difficulties determining what strategy would maximize the new technological capabilities most effectively. The interwar period was one of financial constraint and deliberate moderation. The victors of WWI were particularly prone to war weariness, and attempted to control the interwar arms race through diplomacy. The naval armament conferences were partially successful, were limited successes. By the 1930s as Hitler came to power and Japan started its expansion diplomacy was increasingly unsuccessful. Germany and Japan as "aggressor" nations had clearer strategic visions; they knew who they were going to fight. The clarity of strategic vision drove their rearmament decisions and both countries enjoyed the early success that modernization conferred on their militaries.

Navies in particular faced tough choices. The high cost of ship building, and the long life span of a naval vessel exerted pressure on decision makers. In the interwar period three broad forms presented themselves for consideration. The battleship was familiar, but had not performed well in the most recent conflict. The submarine was antithetical to the prevailing naval mores, but had shown itself usefulness as a commerce raider. Finally, the aircraft carrier represented the unknown. Maritime airpower was certainly useful for reconnaissance, but could planes really sink fleets of battleships? No country fully anticipated the naval combat of the Second World War. Japan and the U.S. did the best in the adoption of aircraft carriers, Germany and the U.S. did the best in the adoption of submarines. Battleships, the dominant preference exhibited by all competitors during the interwar period, fared poorly across the board during the war. The continued organizational preference for battleships during the interwar period was partly due to the entrenchment of Mahan's strategy for control of the sea. The failure of navies broadly was in their lack of recognition that control of the sea was no longer technologically conjoined with battleships. The end had not changed but the means had. The navies of the U.S., Japan, Germany, and Britain differed not in their fundamental—and ultimately flawed—organizational preferences, but rather in how well they tolerated

organizational diversity. It was the diversity of U.S. naval thinking tolerated during the interwar and empowered by visionary leaders that created options when the techno-strategic disintegration of battleships was reveled at Pearl Harbor. Japan and Germany also showed some techno-strategic flexibility, but the Japanese battleship centric plan for Midway and the slow German build-up to Dönitz's 300 submarines created allied opportunities.

On land Britain and France were at a particular disadvantage due to their proximity to Germany. France had misread the techno-strategic situation following the First World War and had developed a defensive doctrine based on the methodical application of artillery fires from an impregnable defensive position. The German push through the Ardennes exposed the weakness, but by then France was occupied and could not reformulate its techno-strategy based on wartime experience. Britain's army was not in a position to contest Germany in a land engagement based on the interwar strategy of avoiding continental commitment. Germany's army had studied the last war in depth, and had made the necessary adjustments to their fighting doctrine to maximize their operational capabilities, but in the larger strategic arena Germany had failed. The mechanized *Panzer* forces were formidable, but they represented a fraction of the force—by 1944 the United States would produce 600,000 trucks to the German 88,000.[592] When the German army was unable to cross the channel, and later denied rapid victory in the Soviet Union the limited nature of their motorization became apparent. Both the United States and Soviet Union had failed to keep pace with the Germans interwar doctrinal developments. However, both would benefit from late modernization and eventually field mechanized forces that would dwarf the Germans. During the interwar period the Germans advanced the nascent combined arms doctrine of the First World War better than anyone, but strategically they blundered by dispersing their efforts over two fronts. The German synchronization of mechanized ground and air forces operating within a decentralized concept of operations based on maneuver and offensive was advanced. However, it was limited strategically. As mentioned the mechanized component was small, the logistical apparatuses remained largely horse driven, and the air component,

[592] Overy, *Why the Allies Won*, 225.

which was thoroughly integrated into a ground support role lacked the range and capacity of a true strategic bombing force. Germany's operational integration was imitable. When the Germans flawed strategy found them competing on multiple fronts they were not able to produce to the degree they needed to avert their impending encirclement.

Strategic air power, as advocated by strategic bombing advocates and separate from the more holistically integrated air doctrine of the Germans, was developed by the U.S. and Britain. The promises of the strategy had outstripped the capabilities of technology. In Britain, whose army was unprepared, the discrepancy between theory and capability presented a real vulnerability. However, Britain's belief in the capability may have also led them to best prepare against the threat. Ironically Britain's successful defense during the Battle of Britain, and the inability of the Blitz to destroy either their production or their will to fight did not affect their continued adherence to strategic bombing. Britain's forays into bombing quickly reveled the disintegration if the techno-strategy of bombing. The targets that would deliver the knockout blow were not readily identified, the planes had difficulty navigating to target, and once at a target their accuracy was deplorable. Furthermore, the vulnerabilities to unescorted bombers were quickly reveled forcing them to fly at night, which compounded all of the problems in navigation and accuracy. The continued support from the Churchill government in light of these problems helps explain how strategic bombing survived in spite of its early techno-strategic disintegration. The Americans joined the British in a combined bombing campaign. American efforts quickly revealed their own problems of integration, specifically, the doctrinal flaw of flying unescorted—tight formations and bristling machine guns were not enough to staunch a fighter onslaught. Over time, strides were made in radar that facilitated bombing, but the real process of integration was less a matter of science and more a matter of morality. Faced with the growing indication that bombers could not precisely target the economic and industrial centers well enough to deliver the knockout blow, the definition of what constituted an economic or industrial center was expanded. "Economic center" became a euphemism for targeting civilian populations. Moreover, the bombing campaign in Germany would not have worked in

the absence of a corresponding successful ground campaign.[593] It is also questionable whether the moral balance will ever shift to the point where an unmitigated attack on civilians would still be tolerable. Atomic bombs were also a direct result of a nearly complete overlap of civil-military function. Without the government's complete support of the Manhattan Project may have been prompted by the fear that Germany was developing a similar weapon. German scientist were unable to garner the high level of government support that the atomic project needed to enrich uranium, and was oriented by the personality of its scientists toward theoretical rather than practical results. In the revolutionary field of rockets Germany had a commanding lead, but failed to recognize that the V-weapons did not yet represent a viable technological solution.

The integration of information and intelligence enabled by radar and other informational technologies profoundly contributed to the success of the allies. Radar was an enabling technology that pushed the integration of other technology. Submarines, airplanes, aircraft carriers, air defense artillery, all benefited from the informational advantage enabled by radar, and the decryption efforts of the various military intelligence agencies.

[593] Robert Anthony Pape, *Bombing to Win: Air Power and Coercion in War* (Ithaca, N.Y.: Cornell University Press, 1996), 311.

V. THE COLD WAR AND BEYOND

The Second World War established the United States and the Soviet Union as superpowers. These powers were opposed in their basic views on to social and political organization. The stage was set for an enduring ideological struggle. The Cold War, as it was eventually dubbed, would inform techno-strategic integration in the United States by creating demands for a military that was ready to fight the Soviet Union on the plains of Europe, but was also capable of fighting more limited engagements in various countries against communist expansion. The balance of these requirements underwent a series of transformations that were informed more by techno-strategic preferences than techno-strategic realities. Indeed, the industrial age techno-strategic paradigm of the Second World War emphasizing an aircraft carrier-centric navy, strategic bombing (with or without nuclear bombs), and a large mechanized land army would prove extremely resilient to change. Furthermore as indicated by Henry Kissinger "we added the atomic bomb to our arsenal without integrating its implications into our thinking. Because we saw it merely as another tool in a concept of warfare which knew no goal, save total victory, and no mode of war except all-out war."[594] Techno-strategic integration in light of this assessment would prove to be a process of reconciliation between having the tools of total war, and enacting a strategy to fight limited wars. This presented nearly two separate but interrelated paths of techno-strategic integration for the United States and eventually the other nuclear powers.

On one hand you had to techno-strategically integrate to fight and win a nuclear war, on the other hand you had to prepare to fight and win wars less than nuclear. Since the two seemed to be fundamentally different this represented a host of problems. WWII had also changed the relationship between the military, science, and technology.[595] The Manhattan Project was the start, but even in light of its transformation to full civilian control, under the auspices of the United States Atomic Energy Commission in 1947, the

[594] Henry A. Kissinger as quoted in: Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 368.

[595] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 407.

relationship between science, technology, and the military continued to grow. The United States dominance as the lone atomic power was soon challenged by the Soviet Union. Further evolutionary development generated more powerful bombs through fusion over fission. Nuclear weapons and their delivery would characterize much of the Cold War technological development. However, as the implications became increasingly grim an uneasy but effective integration of sorts would occur as a doctrine of Mutually Assured Destruction (MAD). The advances in the technology designed to support the impending showdown between the United States and the Soviet Union would also contribute to weapons development in general. Revolutionary rocket technology emerging from the Nazi V2 program would diffuse and missiles would become the foundational projectile technology of modern war. Computer technology and its impact on societies relationship with information represents another area of rapid growth that occurred during this time. Information has always been advantageous; however, following the Second World War technology would rapidly develop to provide increasingly more specific and accurate information. As the Cold War continued information gathering systems would improve. Additionally, the "space race" would create new devices to gather information—satellites. Computers became more and more sophisticated and were eventually interconnected yielding new capabilities for communication and data transference that would serve again to increase information gathering and transference. "Smart" munitions also became technologically viable, increasing accuracy well beyond WWII levels. The transformation following the Second World War has been characterized by Martin van Creveld as the invention of invention; certainly the sheer amount of new and constantly improving technology leads credence to his assessment.[596]

Throughout the entire period there would be increasing strains on the emergent paradigm of the Second World War. Soon after the Second World evidence presented in the *U.S. Strategic Bombing Survey* War indicated that the effects attributed to strategic bombing were not based empirically.[597] Enemy resiliency in Korea and Vietnam would

[596] Van Creveld, *Technology and War: From 2000 B.C. to the Present*, 225.

[597] Maxwell D. Taylor, *The Uncertain Trumpet*, 1st ed. (New York: Harper, 1960), 12.

show the hollowness of strategic bombing, although, in both wars military professionals chalked up its failures to the quantitative restrictions imposed by politicians rather than investigate whether it was the concept that was flawed. Ship-on-ship naval engagements in the Korean and Vietnam War were also limited enough to not raise serious questions about the ascendency of aircraft carriers to the top of the naval hierarchy. However, the vulnerability of surface ships to aircraft was confirmed again in the Falklands leaving questions as to whether aircraft carriers truly represent the best techno-strategic choice for a capital ship since, as a surface ship, they are imminently vulnerable. Submarines represented the alternative choice—a choice the Soviets made. Land engagements also challenged the Second World War paradigm. In Korea and Vietnam, advanced technology was not sufficient to win decisive victories. The Arab-Israeli conflict, a prolonged struggle punctuated by periods of escalated violence between Israel and its surrounding Arab neighbors, provides a further perspective to the changing nature in ground combat. During the Six Day War (June 5–10, 1967) Israel's preemptive attack on Egyptian air power and a heavily armored attack into its Egypt's countryside won a quick victory. However, during the Yom Kippur War (October 6–25, 1973) the same heavily armored techno-strategy was made vulnerable by the Egyptians employment of dispersed teams armed with shoulder fired anti-tank missiles. Israel's victory in this go around was less clear. Similarly in the First Gulf War America and it coalition allies dominated the Iraqi armed forces during a protracted air campaign and short ground war. However, the sheer number of men and materials that were required seems to beg the question of whether we could have achieved the same results with less.

A. IN THE SHADOW OF THE SECOND WORLD WAR: KOREA AND VIETNAM

Shortly after the surrender of Japan, Truman announced the first round of post-WWII military reductions. The Army demobilized nearly 7,000,000 troops from September 1945 to July 1947.[598] Of the remaining 1,070,000, 400,000 were slated to stand-up the Air Force, which became a separate service in September 1947.[599] As in

[598] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 368.

[599] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 368.

Britain during the interwar period, the creation of a separate air component generated inter-service rivalry between the forces and created pressure for the younger service to define its mission in a way that preserved its autonomy. Also, resulting ambiguity over Soviet expansionism in the aftermath of WWII, the U.S. developed a strategy of containment. Containment would start to find its voice in the Truman Doctrine in March 1947.[600] Atomic weapons were central to the U.S. policy of containment, which, in general, sought to deter Soviet expansionism through a powerful (atomically capable) military force while at the same time avoiding the use of that force in actual war.[601]

The U.S. believed that in maintaining an arsenal of atomic weapons it had found the means to support the ends of containing Soviet expansion. It became apparent to senior military leaders was that if they wanted a portion of the limited resources going into defense, then they would need to tie their services' capabilities to the employment of nuclear weapons. Inter-service rivalry for primacy in the atomic age was particularly bitter between the newly independent Air Force and the Navy. Both services began to couch their existing organizational preferences—bigger carriers or better bombers—in atomic terms.[602] The Navy argued that larger carriers would support carrier-based aircraft that could deliver the bomb. That assessment was countered in 1948 when the Air Force fielded the B-36, an inter-continental bomber with a range of 4,000 miles.[603] However, questions about the B-36's survivability were soon raised when the Russians fielded the MIG-15 in 1949.[604] These back-and-forth exchanges were a product of an environment limited in financial resources. Both services felt compelled to make arguments on behalf of their organization that represented their core organizational preferences to get a share of the budget.

Inter-service rivalry reached its apex in April 1949 when the Navy's super-carrier was canceled, leading a group of high-ranking naval officers to openly attack the

600. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 366.

601. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 366.

602 Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 371–372.

603 Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 372.

604 Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 377.

distribution of resources in what would become known as the "revolt of the admirals."[605] Among the charges leveled was the criticism that the Air Force was pursuing one strategy for airpower while ignoring the other roles that airpower could play, such as, close air support. Specifically, the Navy indicted the Air Force for pursuing a concept of operations centered on what the Navy alleged, was a flawed strategy of atomic bombs and the bombers that carried them.[606] The admirals also alleged that the tactical employment of air power had been more important to the WWII victory then the strategic bombing campaign.

Notably however, this was really an indictment against the entire military's nuclear-centric techno-strategy at the time. Furthermore, when the Soviets developed their own nuclear capability in September 1949 the U.S. strategy of annihilation was no longer a one way proposition.[607] The State Department headed by Dean Acheson, who perhaps recognized the implications of the current preferences at work in the military, called for a review of military and foreign policy.[608] President Truman got involved and called upon the Secretaries of State and Defense to relook U.S. strategy in light of the evidence that the Soviets had atomic capability.[609] The result of the inquiry was the issuance, in April 1950, of the National Security Council Report 68 (NSC-68), which laid the groundwork for American Policy during the Cold War. Key in this document was the recognition that defense spending and equipment procurement had been too narrowly focused in the atomic arena.[610] In other words, the U.S. was unprepared to fight anything less than an atomic war.

The tragedy of the Korean War shows some of the failure of integrating the Atomic Bomb into national strategy. The techno-strategic disintegration of atomic weapons had resulted in dissonance between the objectives of the Korean War and the

605. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 377.

606. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 377.

607. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 368.

608. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 379.

609. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 379.

610. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 584–381.

means with which to achieve them; a disintegration that played out dramatically during the war as a contest between Truman and MacArthur. The atomic bomb represented revolutionary technology, and allowed for an unprecedented pursuit of a strategy of annihilation.[611] However, their revolutionary character presented integration challenges to a nation desiring to reduce military forces and expenditures following WWII. Furthermore, as the Korean War represented America's first foray into armed conflict post-WWII, and, perhaps more importantly, in the post-nuclear era of limited wars, achieving techno-strategic integration was largely a product of trial and error. United States policy and conduct in Korea represented a difficult education in the politics of the Cold War; one that would be paid in blood to the tune of roughly 40,000 dead and 100,000 wounded. General Maxwell Taylor as the commander of the Eighth Army would note in a letter to General Ridgway after the armistice that "An outstanding impression from the operations in Korea has been the ineffectiveness or inapplicability of many of our modern weapons to the requirements of the Korean type of limited war."[612]

Part of the disintegration of techno-strategy in Korea lay in the assumptions made about the reasons for, and the end game of, the communist foray into East Asia. Were the Soviets, as conceived by the Truman administration, looking to distract the Americans by opening a front in Korea to gain an advantage in the "real" battleground of Europe?[613] Or, was the incursion into Korea, as MacArthur believed, a test of American fortitude to contain and prevent the spread of communism, and, as such, required an overwhelming response?[614] Depending on how one characterized this conflict determined how one developed one's ends. Truman generally came to represent the first position and MacArthur the latter. Meanwhile, to the military men engaged in the conduct of the brutally cold and bloody campaigns that characterized this "undeclared" war, it was business as usual—depravation, fear, and death.

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611. Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 365.

612 Taylor, *The Uncertain Trumpet*, 15.

613. Robert Endicott Osgood, *Limited War; the Challenge to American Strategy* (Chicago: University of Chicago Press, 1957), 170.

614. Douglas MacArthur, "Testimony before the Senate Armed Services and Foreign Relations Committess," in *Korea: Cold War and Limited War*, ed. Allen Guttmann, 2d ed. (Lexington, Mass.: Heath, 1972), 31.

One of the crucial factors for the Truman administration in determining the American response was the relationship between Russia and China. The crux of the question was the degree to which they were willing to militarily support one another. Given that the United States had recently entered into NATO, and that the Sino-Soviet treaty followed roughly a year later it is reasonable to conclude that Korea may have been conceived as a testing ground for the implications of these treaties. Furthermore, in light of these treaties, it was reasonable and prudent of the Truman administration to be cautious. In contrast to Truman's policy of keeping the Soviets out, MacArthur was focused on decisively winning the war. The restraint that MacArthur was being asked to show fundamentally conflicted with his conception of how to win.[615] Specifically, MacArthur wanted to employ airpower against troop staging areas in Manchuria, he wanted to blockade the coast of China, and he wanted to employ Chinese Nationalist troops in Korea and South China.[616] Rather than simply "resisting aggression," MacArthur wanted to "destroy the potentialities of the aggressor to continually hit you."[617] However, the ways listed above seem in contrast to the stated ends. MacArthur, in his Senate hearing, echoed the themes of the Truman administration for a liberated and unified Korea.[618] But the discordance between the ends expressed by Macarthur and the ways with which he proposed to accomplish them must be viewed critically given that during his Senate hearing he had recently been recalled from Korea. Clearly, MacArthur wanted to expand the war; all three of his measures would have increased the pressure on China. Furthermore, the idea of using Chinese Nationalist troops could have certainly been seen as an effort to incite a revolution in China, something that would have increased the likelihood of a Soviet response. A Soviet response was exactly what the Truman administration wanted to avoid, and, therefore, the measures espoused by MacArthur directly contrasted with the administration's policy. This increasingly became obvious to Truman and ultimately the Joint Chiefs of Staff.

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615. T. R. Fehrenbach, *This Kind of War: The Classic Korean War History*, 50th anniversary ed. (Washington, D.C.: Brassey's, 2000), 271–272.

616. Osgood, *Limited War; the Challenge to American Strategy*, 174.

617. MacArthur, *Testimony before the Senate Armed Services and Foreign Relations Committess*, 31.

618. Osgood, *Limited War; the Challenge to American Strategy*, 42.

Truman, faced with the ramifications of his doctrine, which ultimately implied assistance to populations under threat of totalitarian oppression, found himself on the leading edge of history.[619] Truman was faced with determining exactly how far he wanted to extend his doctrine. Initially the goal of the campaign was to stop North Korean aggression and restore the border at the 38th parallel. This became the UN's policy as evidenced by resolutions on 25 and 27 June 1950.[620] The Truman administration was pursuing a limited war for a limited objective. Furthermore, given the situation in Korea at the time—U.S. and coalition forces on the ropes at Pusan—this objective surely must have seemed like a major undertaking. However, as the coalition forces were successful, and specifically following MacArthur's brilliant landing at Inchon, the aims were broadened. The strategy was expanded first to include operations north of the 38th parallel and later to create a unified Korea with a free government.[621] Truman was talking about containment, but his actions were indicative of expansion.

Ultimately, Truman and MacArthur differed in the willingness to pursue total war.[622] For both figures total war may have implied the use of nuclear bombs. The American army had been designed around the presumption that nuclear weapons would be utilized and therefore manning cuts and equipment neglect predisposed undue suffering in the early phases of the campaign. However, after pushing out of the Pusan perimeter and brilliantly landing at Inchon, the tide of war had turned. MacArthur smelled blood in the water. He ignored the growing evidence that the Chinese were entering the war and ultimately failed to conceive what the ramifications of Chinese intervention would be. When the Chinese did eventually infiltrate across the Yalu, and capitalized on the easy target the American army presented, MacArthur was ready to proceed to total war with its nuclear implications.

619. Osgood, *Limited War; the Challenge to American Strategy*, 167.

620. Osgood, *Limited War; the Challenge to American Strategy*, 171.

621. Osgood, *Limited War; the Challenge to American Strategy*, 171.

622. George C. Marshall, "Testimony before the Senate Armed Services and Foreign Relations Committess," in *Korea: Cold War and Limited War*, ed. Allen Guttmann, 2d ed. (Lexington, Mass.: Heath, 1972), 45–52.

Truman, perhaps more presciently, and faced with the responsibility of the decision and with the knowledge that the Soviet's nuclear program would eventually rival the United States', decided on a more moderate course.[623] Strategically this was the right decision. The deterrent policy that would eventually characterize the cold war had been born. At the time neither side knew how it would work, but the American restraint in Korea was the right first precedent to set.

Following the entrance of the Chinese, MacArthur in his last flash of brilliance, magnificently fought a phased retreat, and then turned the tide once again with a counteroffensive that recaptured Seoul.[624] However, by that time a new star was rising in the eyes of the administration—Lieutenant General (later General) Matthew Ridgway.[625] As the new commander of the Eighth Army, Ridgway was operationally responsible for the quick staunching of the Chinese thrust into Korea, and for getting the American army back on the offensive. Ridgway was capable of producing results within the restrictions of the administration.[626] With the new "old" policy of reestablishing the 38th parallel in mind, Truman selected Ridgway to replace MacArthur.

With a new general in place in Tokyo, the end-game was afoot. What followed was a complete bungling of negotiations. Meanwhile, action on the ground continued through a series of offensives and counteroffensives resembling the First World War.[627] Operationally, America had the advantage; the Chinese had extended supply lines and were predominantly a light infantry force. The United States in contrast was able to mass artillery and airpower. However, "in spite of the overwhelming superiority of the United Nations in the air and on the sea, it was the infantry deployed along the rugged Korean hilltops which determined the issue of victory or defeat."[628] The Chinese and North Koreans successfully manipulated the peace talks to fortify their positions and to

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623. Bernard Brodie, *War and Politics* (New York: Macmillan, 1973), 65.

624. Brodie, *War and Politics*, 80–81.

625. Brodie, *War and Politics*, 80.

626. David Halberstam, *The Coldest Winter: America and the Korean War*, 1st ed. (New York: Hyperion, 2007), 591.

627. Brodie, *War and Politics*, 92.

628 Taylor, *The Uncertain Trumpet*, 15.

consolidate and reorganize. Having fettered away the advantages of strength, the war stagnated. The election of Eisenhower and with it his promise to resume offensive action, and the death of Stalin was enough to break the stalemate. With the guns silenced, an uneasy cease fire went into place, one that continues to this day.

The Korean War illustrates the underlying tension of the dawning cold war. The United States was grappling with its thrust into the center of world politics following its rise to power at the conclusion of WWII. The Korean battlefields were the testing grounds of the United States post-nuclear techno-strategic integration. Against the mass Asiatic armies, who were resistant to attrition, capable of making due with minimum logistical comforts, and employed field craft in the face of technology the American techno-strategic concept of operations was shown incapable of winning. However, America's first foray into the cold war integration of technology and strategy was not enough to expose the techno-strategic disintegration between preparing for nuclear war and then fighting in a limited war. "The ultimate effect of the Korean experience, oddly enough, was not to weaken faith in atomic airpower but rather to strengthen it."[629]

Eisenhower's administration would reformulate techno-strategy in his "new look." The central feature of this strategy was "massive retaliation," a phrase coined by Secretary of State John Foster Dulles in January 1954.[630] Earlier, in May of 1953, the NSC released a formulation of the central features of this strategy in NSC-162.[631] The central feature of this document was the restatement of the commitment to the policy of containment; however, containment was now narrowly defined to the aerial delivery of atomic weapons.[632] "[T]he New Look was little more than the old air power dogma set forth in Madison Avenue trappings and now formally buttressed upon Massive Retaliation as the central strategic concept."[633] Accordingly, all of the military services except the air force were cut. The air force's Strategic Air Command (SAC), whose

[629] Taylor, *The Uncertain Trumpet*, 16.

[630] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 403.

[631] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 401.

[632] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 402.

[633] Taylor, *The Uncertain Trumpet*, 17.

intercontinental bombing capability had been enhanced by the fielding of the B-52 Bomber, grew while other elements of the organization such as troop transport were reduced.[634] The lack of flexibility in a techno-strategy of "massive retaliation" was displayed by the American inability to assist the beleaguered French forces at Dien Bien Phu in the early months of 1954.[635] Importantly, the French garrison at Dien Bien Phu did not need strategic bombing they needed close air support and logistical resupply.[636] The United States would not supply either, and it is questionable whether they could have had they wanted to so limiting was the techno-strategy of "massive retaliation."

"As a doctrine, 'massive retaliation' (or rather, the threat of it) was in decline almost from its enunciation in 1954."[637] "Massive Retaliation" was also further impugned by the Soviet's successful imitation, in this case deliberately cultivated through the use of espionage, of the atomic bomb in 1953. By 1955 the Soviets had developed a capable bombing force and were making significant progress in ballistic missile science.[638] In 1957 the Soviets would demonstrate their lead in rocketry with the successful launch of Sputnik, leading to American fears expressed in the finding of the presidentially commissioned Gaither Committee of a missile gap.[639] The fear that that the Soviets were bypassing the next generation of bombers in favor of a missile delivery system prompted American efforts to both develop its own missiles, its anti-missile missiles, and to harden SAC's ability to survive an attack.[640] However, Sputnik had another impact it prompted the formation of the Advanced Research Projects Agency in

[634] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 403.

[635] Taylor, *The Uncertain Trumpet*, 24–25; Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 404.

[636] Bernard B. Fall, *Hell in a very Small Place: The Siege of Dien Bien Phu* (New York, N.Y.: Da Capo Press, 1985), 458–459.

[637] Thomas C. Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 2008), 190.

[638] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 405.

[639] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 427–429.

[640] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 427–429.

February 1958.[641] Eventually becoming the Defense Advanced Research Projects Agency (DARPA), the creation of an organization specifically committed to the development of technological innovation was a major milestone. Since fully hardening against nuclear attack was unlikely, Oskar Morgenstern, a Princeton game theorist, argued for accelerating the development of the submarine launched Polaris missile because submarines would be harder for the enemy to target on an initial strike.[642] Thus by the conclusion of the 1950s the groundwork for the development of the nuclear triad, and the theoretical foundation of mutual destruction was established.

In light of Soviet advances the techno-strategy of massive retaliation was becoming a two-way proposition. Furthermore, the doctrine was being increasingly questioned by concerned senior military officers. The development of tactical nuclear weapons was espoused by their advocates, such as Henry Kissinger, as presenting options for limited nuclear engagements. General Ridgway, upon his retirement in 1955, argued that tactical nuclear weapons would not solve the problems of superior Soviet and Chinese manpower and were more likely to just prompt a massive nuclear retaliatory response.[643] Ridgway's successor General Maxwell Taylor also voiced dissent upon retirement; advocating a shift away from massive retaliation to a new techno-strategy of flexible response. "Flexible Response should contain at the outset an unqualified renunciation of reliance on the strategy of Massive Retaliation. It should be made clear that the United States will prepare itself to respond anywhere, anytime, with weapons and forces appropriate to the situation."[644] Achieving flexible response necessitated "[i]mproved planning and training for limited war."[645]

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641 Michael P. Belfiore, *The Department of Mad Scientists: How DARPA is Remaking our World, from the Internet to Artificial Limbs*, 1st ed. (Washington, D.C.; New York: Smithsonian Books; Harper, 2009), 52.

642 Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 430–431

643 Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 419.

644 Taylor, *The Uncertain Trumpet*, 146.

645 Taylor, *The Uncertain Trumpet*, 139.

As the Kennedy administration took office in 1961 the techno-strategy of flexible response received political support.[646] Soon after taking office, Kennedy endorsed the invasion of Cuba by a group of American trained and armed Cuban refugees. The plan was not well worked out, and the refugees were quickly subdued by a superior Cuban military. The U.S. was unwilling to escalate the conflict through overt participation and the majority of the invasion force was captured. The failure of the Bay of Pigs invasion was sobering; it also significantly impacted civil-military relationships. Although the plan was generated by the CIA, the Joint Chiefs had not provided sufficient oversight.[647] The Bay of Pigs mishandling, and the subsequent differences of opinion between the military and the administration over intervention in Laos, prompted Kennedy to replace all of the Joint Chiefs except for the Marine Corps.[648] Furthermore, General Taylor, who had headed a committee on behalf of the president to investigate the Bay of Pigs, was brought out of retirement to assume the position of the Chairman of the Joint Chiefs.[649] Kennedy was committed to a flexible response and his actions removed senior military leaders that were unable to transition to his new strategy. The Cuban Missile crisis would further test Kennedy's flexibility. In this test Kennedy would rise to the challenge blending brinkmanship diplomacy, and limited military application to successfully avert the crisis. Kennedy was also pushing the military to further expand its capabilities to wage unconventional wars.

Techno-strategically, flexible response, at the broadest level, required three approaches to security: nuclear deterrence, fighting conventional wars short of nuclear engagement, and fighting unconventional wars. The latter delineated from conventional wars by the increased presence of guerillas or insurgent factions. While it easy to delineate a nuclear war the boundary between conventional and unconventional wars is not always clear, and many conflicts have included an admixture of both conventional forces and guerillas. Eisenhower's new look had set the techno-strategic architecture for

[646] Andrew F. Krepinevich, *The Army and Vietnam* (Baltimore: Johns Hopkins University Press, 1986), 115.

[647] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 450.

[648] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 452.

[649] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 452.

nuclear deterrence, based on mutually assured destruction, in place by narrowly defining U.S. strategy in terms of massive retaliation.[650] However, in the other two areas preparedness was poor. The U.S. Army, who had received very limited funding during the Eisenhower administration, in particular had recast its techno-strategy along organizational preferential lines emphasizing mechanization and offensive maneuver. The army's notion of limited war was itself limited. The object of war was unconditional surrender made possible by the defeat of the enemy's field armies and means of production.[651] Although Kennedy clearly saw war against guerrillas and insurgents as necessitating "a whole new kind of strategy, [and] a wholly different kind of force," the opinion of senior army leaders was that a force equipped for conventional war would readily defeat an irregular force.[652] The army would eventually test this techno-strategic assumption in Vietnam.

American involvement in Vietnam had been going on since the establishment of the Military Assistance Advisory Group (MAAG) in 1950.[653] However, the effort was small, totaling just 342 individuals in 1954.[654] As the French withdrew following Dein Bein Phu the American advisory effort increased. Rather than working with the Army of the Republic of Vietnam (ARVN) to develop the type of force needed to be successful fighting as counterinsurgents in the jungles, the U.S. Army advisory effort built the ARVN in its own image. Accordingly it consisted of the techno-strategic preference for large scale maneuvers organized around heavy fire power and mobile armored forces.[655] Meanwhile, the insurgency continued to grow, by December of 1960 the insurgents were openly challenging the South Vietnamese government. Kennedy was trying to implement a strategy that could continue to check communism by fighting a limited counterinsurgent war, but the army continued to resist the necessary techno-strategic

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650 Krepinevich, *The Army and Vietnam*, 27.

651 President Kennedy as quoted in Krepinevich, *The Army and Vietnam*, 30.

652 Krepinevich, *The Army and Vietnam*, 36–37.

653 Krepinevich, *The Army and Vietnam*, 18.

654 Krepinevich, *The Army and Vietnam*, 18.

655 Max Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power* (New York: Basic Books, 2002), 288.

paradigm shift that would enable success. Kennedy clearly identified the friction in civil-military relations, and called a meeting with the army's commanders in November 1961 where he expressed his desire for the army to prepare itself more for counterinsurgency.[656] However, the army may have been able to weather the criticism of its preparedness for counterinsurgency because of President Kennedy's continuing support for Special Forces.

Special Forces had existed formally since the stand-up of 10th Special Forces Group on 20 June 1952, and it could trace its lineage back to the Office of Strategic Services in WWII.[657] Kennedy's emphasis on counterinsurgency and guerrilla operations however, was critical to the amount of attention Special Forces received and he even recognized their distinctive headgear—the Green Beret. Under Kennedy Special Forces grew and their role expanded.[658] The army may have been content to slow roll the president's larger exhortations for a counterinsurgent force because they could point to a subcomponent within the army that was specially tasked to perform that mission.[659] Meanwhile, the rest of the army could go on preparing to fight "real" wars. Army doctrinal publications related to fighting a counterinsurgency, such as FM 31–21 *U.S. Army Counterinsurgency Forces*, were published through the Special Warfare Center and oriented toward Special Forces not the larger army.[660] Training for counterinsurgency was also woefully lacking—an infantry lieutenant's initial entry training devoted only 16 percent of the available training time to counterinsurgency in 1965.[661] Furthermore, even Special Forces failed to fully emphasize counterinsurgency over their organizationally preferred mission of unconventional warfare, which was designed to develop and employ guerillas in support of a larger conventional military campaign.[662]

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[656] Krepinevich, *The Army and Vietnam*, 31.

[657] Krepinevich, *The Army and Vietnam*, 100–102.

[658] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 456.

[659] Krepinevich, *The Army and Vietnam*, 112.

[660] Krepinevich, *The Army and Vietnam*, 112.

[661] Krepinevich, *The Army and Vietnam*, 49.

[662] Krepinevich, *The Army and Vietnam*, 74, 103.

Kennedy approved the MAAG's counterinsurgency plan in January 1961, which under Lieutenant General McGarr represented a conventional approach stressing offensive action against the Viet Cong (VC).[663] Shortly thereafter the request for more troops started coming—a trend that continued until after the Tet Offensive in 1968. Before committing to more troops, Kennedy sent General Taylor and Walt Rostow from the State Department to Vietnam to survey the conflict and provide their recommendations.[664] Taylor supported increasing material assistance to the ARVN to enable their abilities to conduct search and destroy operations. Taylor correctly identified that the communist insurgents were employing a style of warfare that employed a concept of operations that negated many of the U.S.'s conventional military advantages, nevertheless, his prescriptions for employment contained all of the major conventional features—firepower, mobility, and bombing.[665]

Kennedy accepted Taylor's recommendations in November 1962, that same month the Military Assistance Command Vietnam (MACV) was established, and placed under the command of Lieutenant General Paul Harkins.[666] MACV was still focused on advising, however, the advising was in accordance with the favored techno-strategic paradigm of large offensive operations. This emphasis may have exacerbated the insurgency in two ways. First it was undoubtedly heavy handed, thereby generating resentment that could be used for VC recruiting efforts. Second, it concentrated a large number of the militarized South away from their villages where they may have been able to insulate the population against the inroads of the insurgency. Contrasting concepts of operations existed. First, the Strategic Hamlet program, conceived in part by the British Advisory Mission under R.K.G. Thompson, advocated clearing areas of insurgents and then arming and training the local citizenry to prevent the VC from recapturing the

[663] Krepinevich, *The Army and Vietnam*, 58–59.

[664] Krepinevich, *The Army and Vietnam*, 61.

[665] Krepinevich, *The Army and Vietnam*, 62.

[666] Krepinevich, *The Army and Vietnam*, 64.

area.[667] The concept is fundamental counterinsurgency, but it was undermanned as the ARVN forces necessary to secure the population were pulled to support large scale operations.[668]

A second alternative concept the Civilian Irregular Defense Groups (CIDG) was orchestrated by the CIA and ran by U.S. Army Special Forces. The CIDGs showed promise—the advisory effort when it was geared toward mentoring locals to defend themselves in their local area actually limited VC operations significantly.[669] However, the control by the CIA eventually irked the army into taking over the program in July 1963. The CIDG corps of experienced counterinsurgent Special Forces advisors was soon re-tasked to conduct unconventional warfare tasks that were more complimentary to MACV's strategy of offensive action.[670]

The death of President Diem during a coup on November 1, 1963 strengthened the communist rhetoric—attacks would steadily increase through 1964 and 1965.[671] However, it was the assignation of President Kennedy 21 days later that may have had the bigger impact on the long term outcome of Vietnam. Kennedy, perhaps due to reflection on the Bay of Pigs failure, was a forceful instrument of change in the military. Kennedy had a strategic vision for the military and he knew that it conflicted with the army's accepted notion of how to fight; nevertheless, he drove them to change. Unfortunately, Kennedy's influence was cut short—the techno-strategic paradigm of large scale offensive operations empowered by technologically enhanced firepower and mobility would survive him.

Kennedy's presidential successor, Lyndon B. Johnson, used an attack on the *Maddox* in the Gulf of Tonkin on August 2, 1964 to receive Congressional authorization to protect U.S. interests in Southeast Asia.[672] Shortly thereafter, following the election in

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[667] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 289.

[668] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 289.

[669] Krepinevich, *The Army and Vietnam*, 70–71.

[670] Krepinevich, *The Army and Vietnam*, 74.

[671] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 461.

[672] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 290.

1964, Johnson moved to make good on retaliating for the Gulf of Tonkin incident. In March of 1965 Operation Rolling Thunder began. Rolling Thunder, a protracted strategic bombing campaign against the North Vietnamese's ability to wage war, would become one of the enduring features of the techno-strategic disintegration of the conflict. A long term bombing campaign necessitated staging bases in South Vietnam, which in turn required forces to secure them.[673] General William Westmorland, who replaced Harkins at MACV in June 1964, would request 44 battalions for operations in 1965. This request in some ways represented the complete techno-strategic shift away from the potentially promising counterinsurgent concepts of Strategic Hamlets and CIDGs to the favored techno-strategic concept of search-and-destroy, firepower, and bombing.

Central to the search-and-destroy mission was the UH-1 "Huey" helicopter—it would become the iconic technology of the Army's techno-strategic approach to Vietnam. Vietnam was not the first use of helicopters; they had seen limited use in the Second World War and again in Korea. The helicopter proved capable for a variety of tasks in its early use, but medical evacuation proved to be its strong suit.[674] Capable of vertical takeoff and descent, the helicopter was able to extract casualties and delivery supplies in terrain otherwise only accessible by foot or pack animal. The helicopter's transformation from niche medical evacuation platform to its enlarged role as a combat troop transport and CAS platform occurred during the lean years of the Eisenhower administration. Lieutenant General James M. Gavin advocating along similar lines as Generals Ridgway and Taylor argued that the "new look's" myopic view of war had had serious impacts on the army's limited war capabilities.[675] Gavin's experience as the 82nd Airborne Division commander during Operation Market Garden in the Second World War led him to stress the importance of aerial mobility—a role that helicopters could be expanded to perform.[676] Central to the army's development of its "airmobile"

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[673] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 463.

[674] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 176.

[675] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 422–423.

[676] Weigley, *The American Way of War; a History of United States Military Strategy and Policy*, 423–424.

techno-strategy was the framing of the capability in the context of preparation for the conventional showdown with the Soviet Union on the plains of central Europe.[677] The enduring inter-service rivalry between the U.S. Army and Air Force also contributed to the problem. The Air Force's continuing organizational preference for bombers over transport and CAS air frames prompted the army to develop its own capabilities. Throughout the 1950s the army's aerial capabilities grew, thus increasing pressure on the air force to retain CAS or risk losing some of it budgetary support.[678]

Secretary of Defense Robert McNamara, again showing the Kennedy administration guiding hand in civil-military relations, forced the army to reevaluate airmobility after he determined that the army was ignoring it.[679] Airmobility advocates, working in conjunction with Secretary McNamara, convened a board in 1962 on presided over by the XVIII Airborne Corps Commander General Howze[680] The Howze board's recommendation was to concentrate 316 helicopters, a little more than a third of which were to be attack helicopters, into an air cavalry brigade.[681] The groundwork that would eventually become the 1st Air Cavalry Division—the first divisional organization sent to Vietnam in 1965—had been laid. However, tension continued to increase with the air force. The air force had convened a separate board which had, predictably, refuted the findings of the Howze board.[682]

The continuing friction between the services led to variety of field testing. The army's air assault demonstration, which lacked testing conditions against insurgent or guerilla forces, decided the issue in the army's favor. The airmobility concept, conceived of as providing mobility on a conventional battlefield, was tested against conventional conditions.[683] During testing the army only devoted one out of the eight total tests to a

677 Krepinevich, *The Army and Vietnam*, 113.

678 Krepinevich, *The Army and Vietnam*, 114.

679 Krepinevich, *The Army and Vietnam*, 115–116.

680 Krepinevich, *The Army and Vietnam*, 119.

681 Krepinevich, *The Army and Vietnam*, 120.

682 Krepinevich, *The Army and Vietnam*, 121.

683 Krepinevich, *The Army and Vietnam*, 124–125.

lower intensity scenario, and that scenario used the airmobile force in a search-and-destroy role.[684] Still even then there were some indications of techno-strategic disintegration. Finding insurgent forces and securing the aircraft staging bases posed difficulties.[685] Both are particularly problematic from a counterinsurgency perspective because the insurgents generally look like everyone else, and troops used to secure a base are not available to secure the population. However, helicopter enhanced airmobility had arrived.

The two central techno-strategic features of Vietnam—airmobility and strategic bombing—were in place by 1965. The requirement for troops to secure the air bases for the bombing campaign opened the door for a build-up of force that would reach 536,000 Americans augmented by 670,000 South Vietnamese in 1968.[686] Meanwhile a daily average of 800 tons of bombs would be dropped during operation Rolling Thunder, yet the impact to North Vietnam was negligible.[687] So central was the techno-strategy of bombing enshrined that its failure was chalked up to political restrictions in target selection. Upon returning home from his command of the 8th Tactical Fighter Wing based in Thailand, Colonel (later Brigadier General) Robin Olds, a WWII and Vietnam fighter ace, sat down with President Johnson to debrief him. When asked what he thought should be done Olds replied, "'mine the harbors, drop the road and rail bridges on the Chinese border, get the supply dumps in Cambodia, and most important, totally destroy the seat of government in Hanoi…the way to end this war is just to win the damned thing!'"[688] The commitment to bombing from a career fighter pilot is itself indicative of the acceptance of the techno-strategic paradigm of strategic bombing. Fundamentally, the problem was a lack of understanding about what the most important target was in a counterinsurgency. In the same conversation as above Olds, making his case for a less restrictive bombing campaign, explains to President Johnson that the North

684 Krepinevich, *The Army and Vietnam*, 126.

685 Krepinevich, *The Army and Vietnam*, 126.

686 Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 298.

687 Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 291.

688 Robin Olds, Christina Olds and Ed Rasimus, *Fighter Pilot: The Memoirs of Legendary Ace Robin Olds*, 1st ed. (New York: St. Martin's Press, 2010), 344.

Vietnamese effort needed "'manpower, willpower, and industrial power. They possess the first two requirements in abundance, but they have little industrial capacity and must rely on others for their material needs.'"[689] There are two problems in this assessment. First, many of the people being relied upon by the North Vietnamese were in fact the South Vietnamese citizenry. Second, Olds is implying that by more effectively targeting industrial capacity the U.S. would impact manpower and willpower. This was unlikely, and is a reflection of part of the problem inherent in the Vietnam War of thinking about the enemy's strategy in American terms.

The adherence to large-scale land operations showed the same pattern. Having designed the South Vietnamese force along American lines, Westmoreland was able to circumvent questioning strategy, and instead chalked up failure to the inferior soldiering of the South Vietnamese.[690] But the problem was not the soldiers it was the strategy. Massing forces in large-scale operations to find, fix, and finish the enemy could not work if the enemy was able to disappear once the battle shifted unfavorably against him. Furthermore, the conventional approach affected troop ratios unfavorably—the majority of the deployed force were from the logistical, support and maintenance specialties.[691] Of the 550,000 only 80,000 represented the actual combat forces.[692] The adherence to the organizationally preferred techno-strategy created a huge demand for forces but to no avail—the enemy, except in a few instances, would just not concentrate long enough to be destroyed.

Both bombing and large-scale massed assaults played to the North Vietnamese's strengths. North Vietnam had been fighting a protracted insurgency since before the Second World War. During the course of the WWII, Ho Chi Minh and Vo Nguyen Giap would meet and form an enduring relationship—their concepts of operations would

689 Olds, Olds and Rasimus, *Fighter Pilot: The Memoirs of Legendary Ace Robin Olds*, 344.

690 Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 294.

691 Krepinevich, *The Army and Vietnam*, 176.

692 Krepinevich, *The Army and Vietnam*, 176.

successively defeat both the French colonials and the Americans.[693] Giap's exposure to Mao Zedong's conceptualization of a people's war formed the basis of the strategy, but Giap extended it further to include blending urban and rural areas and also to include coordinated dispersed attacks if the conditions were right.[694] As the Americans escalated their involvement during the early 1960s, Giap and Ho were busy expanding the North Vietnamese Army and continuing to build a base of support in the South for the Viet Cong.[695]

Logistical and personnel movement from North Vietnam to South Vietnam along the Ho Chi Minh trail became a critical part of the conflict, a fact that Giap would readily acknowledge.[696] The Ho Chi Minh trail was essentially a network of trails and supporting roads between Laos, Cambodia, and Vietnam. The trail was resilient to bombing, if one area was discovered the trail would change, bypassing the current hot-spot but always moving steadily southward.[697] Trail conditions were austere. Food was in constant shortage, single grains of rice were reclaimed if dropped.[698] The trail like conditions and the incessant bombing made vehicle traffic difficult, so bicycles were modified to distribute supplies across the entire frame, and then the bike was pushed down the trial by replacing the seat and handle bars with a stick to better control the load—individual loads were generally between 100–150 kilograms.[699] The manpower and willpower involved in this example of techno-strategic integration was more than enough to make up for the lack of industrial power.

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693 Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 229–230.

694 Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 230–231.

695 Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare have Shaped our World*, 229–230.

696 James G. Zumwalt, *Bare Feet, Iron Will: Stories from the Other Side of Vietnam's Battlefields*, Haback ed. (Jacksonville, FL: Fortis Pub., 2010), 222.

697 Zumwalt, *Bare Feet, Iron Will: Stories from the Other Side of Vietnam's Battlefields*, 222.

698 Zumwalt, *Bare Feet, Iron Will: Stories from the Other Side of Vietnam's Battlefields*, 234.

699 Zumwalt, *Bare Feet, Iron Will: Stories from the Other Side of Vietnam's Battlefields*, 246.

Although the air assault tactics proved difficult to overcome, the helicopters rather loud approach, slow rate of flight, and vulnerability to small arms eventually led to it being countered in another example of Vietnamese field craft.[700] Over the course of the war upwards of 3,000 helicopters were destroyed.[701] The Cu Chi tunnel system is another example of the Vietnamese's larger solution of avoiding battle on anything other than favorable terms. In some ways it was like an underground version of the Ho Chi Minh trail in that the Cu Chi tunnels (one of the many underground fortifications) were a network of underground facilities tied into an above ground village network.[702] Construction of the Cu Chi tunnels began in 1946; by the time the U.S. started arriving in force in 1965 they had transformed into a formidable fortification. The Cu Chi tunnels, and other tunnel networks, were used to support a concept of operations whereby U.S. forces would be engaged upon landing, as the U.S. force pursued the enemy, the guerilla fighter would simply disappear thwarting the success of the hammer and anvil style operations.[703] Against a different concept of American employment however, the guerillas would find no such luck.

In 1965, in a concept reminiscent of the Strategic Hamlets the U.S. Marine Corps began its Combined Action Program (CAPS). The small size of the program—never more than 2,500 Marines—makes it difficult to evaluate CAPs against the conventional effort employed by Westmoreland. This concept would pair between 12 to 15 marines with a village, where the marines would live amongst the population establishing a village militia to increase the security and taking part in the everyday activities of its inhabitants.[704] It was dangerous duty, but over time in the areas where it was employed the CAPs achieved success. It is fair to question whether if this concept had been employed on a larger scale in lieu of the search-and-destroy strategy what the outcome might have been.

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[700] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 35.

[701] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 192.

[702] Zumwalt, *Bare Feet, Iron Will: Stories from the Other Side of Vietnam's Battlefields*, 295.

[703] Zumwalt, *Bare Feet, Iron Will: Stories from the Other Side of Vietnam's Battlefields*, 298.

[704] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 304.

In 1968 Giap would synchronize the Tet Offensive ultimately starting the end game of American involvement in Vietnam. Tet, a series of attacks during the lunar New Year, broke a cease fire agreement, and the surprise worked initially. However, the enemy's mass presented the type of target that the U.S. was aptly designed to confront. But even as the balance of combat swung back in favor of the U.S., the balance of support from the U.S. waned. Walter Cronkite would remark in a conclusion of his CBS nightly news segment that "It seems now more certain than ever that the bloody experience of Vietnam is to end in a stalemate."[705] Johnson would not seek reelection in 1968. Richard Nixon and Creighton Abrams would inherit the war from Johnson and Westmoreland, but by that time it was probably too late to reverse the course.

Giap would unleash another synchronized offensive in 1972, another election year, dubbed the Easter Offensive. By this time many of the American forces had departed. The South Vietnamese Army supported by U.S. air support, however, proved up to the task of holding against the North.[706] The check of the Easter offensive, and a renewed bombing campaign created some diplomatic bargaining room eventually leading to the Paris Peace Accord on 27 January 1973.[707] This was not a victory for the North, but it soon would be. The South had been trained in and had come to rely on the techno-strategic paradigm of large conventional operations supported by a superior capacity for aerial support. When the U.S. withdrew that support the South was imminently vulnerable. During the next invasion in 1975 the North would achieve its goal of unifying the country.

Vietnam had a profound effect on the U.S. Defeat at the hands of a decidedly technologically inferior foe had to be reconciled. Unfortunately the reconciliation focused on how the American military had been restricted politically from doing its job.[708] This analysis implied that if the military had only been able to invade the North

[705] Walter Cronkite as quoted in Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 309.

[706] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 312.

[707] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 312.

[708] Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 315.

or to expand the bombing campaign against a wider set of targets it could have won it as a conventional war. Problematically, this analysis perpetuated the notion that counterinsurgency did not require a different concept of operations only a commitment to fully apply the organizational preferred techno-strategy of total war. Accordingly counterinsurgency would languish while the army consoled itself that it had "never [been] defeated…on the battlefield."[709]

B. THE CONTINUING COLD WAR, OTHER CONFLICTS, AND THEIR IMPLICATIONS

1. The Arab-Israeli Conflict

Roughly during the same time period that the U.S. was fighting in Vietnam, the Israelis were in continuing struggle to with their surrounding Arab neighbors: Jordan, Syria, and Egypt. Essentially, starting at the conclusion of the Second World War the Arab-Israeli conflict escalated throughout 1947–1949. In May 1948, upon the creation of an Independent Jewish state, the Arab-Israeli war—known in Israel as The War of Independence—began in earnest. The eventual 1949 armistice did little to staunch the violence. Widespread Jewish immigration to Israel following statehood, and an enduring ethnic tension created a security situation of continuing hostility. Major flares ups would occur in 1956, 1967, 1969, and 1973. In contrast to Vietnam, the Arab-Israeli conflict in this time period would consist of predominately armored and aerial combat, although there were limited naval engagements. The security situation in Israel was clear in a way that the Cold War never was for the U.S. America's commitment to containing communism, although projected to take place in Europe, could occur anywhere. Israel in contrast, could concentrate on defending its borders in open desert terrain.

Israel's preference for armor was established during the Suez Crisis in 1956. However, Israeli armor doctrine differed from what had emerged elsewhere following the conclusion of the Second World War. The Israeli Defense Force (IDF) was predominately equipped with the larger Centurion tanks which had been built toward the

[709] Colonel Harry Summers in a comment to a North Vietnamese colonel as quoted in: Boot, *The Savage Wars of Peace: Small Wars and the Rise of American Power*, 313.

conclusion of the Second World War.[710] The Centurion was more heavily armored and designed specifically to fight German heavy tanks.[711] Rather than adopting the combined arms approach, which employed infantry, armor, and artillery in concert the IDF built homogenous tank units.[712] Advocates of this approach, such as Yisrael Tal, argued that the visibility in the open terrain of Israel would favor the advantages of armored mobility and firepower.[713] The Israeli Air Force (IAF) formed the other major component of the Israeli techno-strategy. Rather than focus on developing a strategic bombing capability the IAF was organized and equipped to perform air-to-air and air-to-ground missions. Furthermore, and again highlighting the clarity of the strategic situation, the IAF knew the preliminary target of a war with Egypt would be the Egyptian airfields.[714]

Tension rose as Israel made progress toward achieving nuclear status. Egypt began posturing on the Syrian border in May 1967. The IDF activated its reserves brining up its strength to nearly 275,000.[715] Although Israel would face an Arab coalition, the lynchpin of that coalition was Egypt. Egypt had a modernized military consisting of mostly soviet equipment. Particularly threatening was its 385 aircraft to which, in contrast, Israel could muster only 200.[716] However, Israeli intelligence knew the exact composition and disposition of the Egyptians, which largely negated their advantages in number. On 5 June 1967 Israel launched a preemptive aerial assault against the Egyptian airfields destroying 286 planes before they were even airborne.[717] Israeli tanks also entered the fight, skillfully out gunning their adversaries and pushing

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[710] Martin Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 1st ed. (New York: Public Affairs, 1998), 160.

[711] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 160.

[712] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 160.

[713] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 160.

[714] Michael B. Oren, *Six Days of War: June 1967 and the Making of the Modern Middle East* (Oxford: Oxford University Press, 2002), 171.

[715] Oren, *Six Days of War: June 1967 and the Making of the Modern Middle East*, 168.

[716] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 181–183.

[717] Oren, *Six Days of War: June 1967 and the Making of the Modern Middle East*, 176.

deep into the Sinai Peninsula. Further gains were made in the Golan Height, the Gaza Strip, the West Bank, and East Jerusalem. The war was swift and decisive, but Israel's victory presented complications.

The question about what to do with the acquired territory of Syria, Egypt, and Jordan was problematic, a situation made worse when the Arab league summit in Khartoum produced its "three no" resolution—no negotiation, no peace, and no recognition. However no amount of avoidance could prevent the Arab coalition from recognizing that they had been thoroughly trounced.

Israel would occupy the captured territory in the Gaza Strip, along the Sinai Peninsula, in the West Bank, and in the Golan Heights. The occupation and rapid overwhelming victory would change Israel's strategic situation. However, the technological choices for a predominantly heavy armor force complimented by a strong IAF would persist. Israel's new borders would be more defensible, which contrasted with the national techno-strategic focus on offense—embodied in the 1967 campaign. Defensive possibility would stretch the Israel's techno-strategic paradigm in three ways. First it would siphon off some of the IDFs available manpower in fortifications. Second, if and when the fortifications were attacked the fortifications would need to rely on IAF assistance to prevent them from being captured, potentially preventing the IAF from pursuing its offensive role of gaining air superiority.[718] Finally the new territory extended Israel's supply lines, thus potentially preventing rapid reinforcement of an armored breakthrough. There were other difficulties with Israel's techno-strategic paradigm that were not made clear due to the shortness of the 1967 "Six Day War." The weaknesses of employing armor without infantry support were obscured by the shortness of the war and the high operational tempo of the IAF—3,279 sorties over the 132 hours of the war—would not be sustainable in a protracted fight due to inevitable maintenance requirements.[719] Civil-military relationships were also impacted by the dramatic victory as the prestige of the military increased so did their clout in military related decision making.

[718] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 203.

[719] Oren, *Six Days of War: June 1967 and the Making of the Modern Middle East*, 305–306.

Conscription terms were increased to meet the demands of occupation, spending increased, and the number armor brigades increased from 21 to 26—in some cases infantry units were even reorganized as armor units.[720] The Six Day War also increased the Cold War tension. Although Israel's alignment with America and the west, and Egypt's alignment with the Soviet Union preceded the 1967 war, it was during the post war rebuilding that the alliances were solidified. The Soviet support to Egypt included upwards of 20,000 advisors, as well as a robust equipment package that more than made up for its combat losses.[721] Israel's rearmament and modernization program was overwhelmingly directed toward its air and armored strength. The War of Attrition, starting in March of 1969 and ending in August 1970, highlighted the continuing tension between Israel and Egypt.

During the War of Attrition the violence on the ground and in the air escalated. Aerial combat was often short and decisive; however, the Soviets had provided the Egyptians with modern—electronically guided—antiaircraft missile defenses.[722] The Israelis, flying U.S. F-4 Phantoms, were accordingly provided with the latest electronic countermeasures developed in Vietnam, where the Americans were frequently targeted by similar Soviet equipment.[723] Meanwhile, on the ground the Egyptians were working to harden their Surface to Air Missile (SAM) sites. Soviet intervention increased as Soviet pilots took to the air in the latest generation of MIG-21s. Soviet intervention led to increased external pressure for a cease fire, which was enacted in August 1970. The cease fire cooled the active hostilities, but almost immediately the Egyptians began improving, and consolidating their SAM sites—a sure indication that future Israeli aviators would have to contend with sophisticated missile defenses. The War of Attrition however, was merely a preliminary for the next confrontation, which would prove to be the most violent yet.

[720] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 205.

[721] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 211.

[722] Chaim Herzog, *The War of Atonement* (London; Pennsylvania: Greenhill Books; Stackpole Books, 1998), 9.

[723] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 214.

The Yom Kippur War commenced on October 6, 1973. Although the war was again fought against mainly Egyptian and Syrian forces, with broad Arab support the shifting techno-strategic situation is best highlighted in the actions of the Egyptian in the Sinai Peninsula. In contrast to the 1967 intelligence that led to the preemptive attacks on the Egyptian airfields, the intelligence assessment in 1973 was not as clear. Although there were indications that Egypt was marshaling, the chief of intelligence concluded that they were not going to attack.[724] By October 4th however, it was generally clear that attack was imminent. The Prime Minister, Golda Meir, was urged to launch a preliminary strike similar to the one that had devastated Egypt in 1967; however, she declined fearing that allies would not come to the aid of Israel if it was perceived to be the aggressor.[725] The lack of preemptive airstrike was not the only difference between the two campaigns. Egypt had developed a concept of operations to neutralize the advantages of Israeli armor that took advantage of dispersion in the face of armored mass. The Egyptian plan involved the infiltration of 8,000 troops armed with the latest Antitank Guided Missiles (ATGM).[726] Israel's reliance on armor without infantry support made it especially vulnerable to a dispersed force, and the capabilities of ATGMs had shifted the technological balance. ATGMs increased the amount of firepower accessible to an individual, thus making the tank vulnerable to infantry. Tanks still have the advantage in mobility and protection, but ATGMs shifted the balance and when artfully employed they could prevent rapid unsupported armored movement. The Egyptians showed good insight in the integration of ATGMs. The Americans, through proxy, would use a similar dispersed force of men armed with anti-aircraft Stinger missiles against the Soviets in Afghanistan during the 1980s. Furthermore, Egypt's attention to SAMs greatly blunted Israeli IAF advantages, at least initially. However, Egypt's early successes would be short lived. The IDF was able to adjust its tactics to a more combined arms doctrine where infantry and artillery were employed to clear areas

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[724] Herwig, *Innovation Ignored*, 49.

[725] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 224.

[726] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 194.

of potential ATGM gunners.[727] Second, as the Egyptian front extended past the coverage of their SAMs the IAF was able to renew its onslaught unfettered.[728] However, in spite of the eventual Egyptian losses, the shifting techno-strategic dynamic enabled by ATGMs and SAMs—both of which offer increased capability to dispersed forces should not be ignored. Armor and airplanes both prevent large targets, the diffusion of man portable and increasingly capable shoulder fired missile systems suggest that their vulnerability to a dispersed force is increasing.

2. Surface Ships Airplanes and Submarines: the Falklands War

While Korea, Vietnam, and the Arab/Israeli conflict all had naval components they were primarily land and air campaigns. However, in 1982 the first sustained major naval action since the Second World War took place off of the Falkland Islands between the United Kingdom and Argentina. While the Falklands War, from April to June 1982, was also fought on the ground in the Falkland Islands, this discussion will be restricted to the naval action. Given the shortness of the overall campaign the naval action in the Falklands was especially violent. The British lost *Sheffield, Coventry, Ardent, Antelope, Atlantic Conveyor,* and *Sir Galahad*.[729] Other ships were severely damaged, and more would have been lost had "the Args' bombs…been properly fused for low-level air raids."[730] The British response to the Argentinian invasion of the Falklands was overwhelmingly naval, as such; the composition of the fleet reflected the techno-strategic preferences of the Royal Navy. When the crisis erupted Admiral Henry Leach informed Prime Minister Margret Thatcher that a carrier task force consisting of the HMS *Hermes* and *Invincible* and their supporting destroyers and frigates could be ready to leave in two days.[731]

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[727] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 232.

[728] Van Creveld, *The Sword and the Olive: A Critical History of the Israeli Defense Force*, 234.

[729] Sandy Woodward and Patrick Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander* (Annapolis, Md.: Naval Institute Press, 1992), xviii.

[730] Woodward and Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, xviii.

[731] Woodward and Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, xi.

From the start of the conflict it was clear that the British, like their American allies, had techno-strategically built their navies around the aircraft carrier following the Second World War. This choice was not a forgone conclusion, as the Soviet Union, in contrast, chose the submarine.[732] Events in the Falklands would raise questions about which was the better choice, for while the majority of the fleet would consist of surface vessels, the British also deployed three submarines *Spartan*, *Splendid* and *Conqueror*.[733] On the 2 May *Conqueror* would sink the Argentinian *General Belgrano*—the fear of further submarine attacks would compel the Argentine Navy to return all of their ship to port for the remainder of the conflict.[734] One submarine had, in some sense, defeated an entire naval task force.

The British, having largely prepared their navy for countering the Soviet submarine threat, showcased an impressive array of submarine detection technology including networked system of electronic sensors, and including helicopters equipped with a sonar sensors that could be dangled in the ocean.[735] Helicopters would also act as missile decoys, after the *Sheffield* was sunk by an Exocet—a radar-guided surface skimming anti-ship missile. Also, in a return to their original functions in the Korean War, helicopters would provide logistical and medical evacuation, as well as facilitating ground mobility both on land and between ships.[736]

The combat action that took place at sea was heavily carrier-centric. However, since the Argentine navy had been thwarted by the submarine threat the fleet action primarily consisted of managing the air wings to ensure the maximum amount of offense and protective coverage. The British opened with a bombing campaign on 1 May 1982 directed against the airfield at Port Stanley—a feat which required a 7,800 mile round trip

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[732] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 60–61.

[733] Bryan Perrett, *Weapons of the Falklands Conflict* (Poole, Dorset; New York, N.Y.: Blandford Press; Distributed in the U.S. by Sterling Pub. Co., 1982), 20.

[734] Woodward and Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, 159–164.

[735] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 205.

[736] Lawrence Freedman, *The Official History of the Falklands Campaign*, Vol. II: War and Diplomacy (Abingdon: Routledge, 2005), 728–729.

flight from the Ascension Islands and required 17 inflight refuelings.[737] Subsequent aviation raids would continue to target the air defense capabilities and runways at Port Stanley and Goose Green, an alternate Argentinian staging area.[738] However, these raids would be conducted by the Sea Harriers of *Hermes* flight wing. The British bombardment of the Falkland runways forced Argentina's Air Force to fly its support from the mainland, which dramatically reduced its time on station. Main land Argentina was just close enough that it could reach the British fleet, which had carefully positioned itself to be nearly out of range.[739] However, on the opening day of the conflict the British fleet weathered a full on assault of 40 aircraft.[740] Following the growing trend, the aerial combat was heavily missile based.

Missiles, supported by an increasingly complex sensor array and onboard targeting assistance from radar or infrared homing, emerged as one of the defining features of the Falklands. Admiral Woodward notes that the "Sidewinder was a better air-to-air missile than anything they [Argentinians] had."[741] The British Harriers armed with Sidewinders had achieved dominance in air-to-air combat, but many of their Argentine "kills" were fighter-bombers with dwindling fuel seeking to sink ships not to dog fight.[742] Furthermore, the amount of airpower tasked for self-defense reduced the amount of available CAS.[743] However, missile capabilities, especially those associated with ship based air-defenses, were exaggerated in the immediate aftermath of the conflict. In one after action report conducted by the Ministry of Defense (MoD) in 1982, the Rapier (a surface-to-air missile) was credited with a 49 percent kill ratio.[744] Reports on

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[737] Macksey, *Technology in War: The Impact of Science on Weapon Development and Modern Battle*, 204.

[738] Woodward and Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, 135–136.

[739] Perrett, *Weapons of the Falklands Conflict*, 85–86.

[740] Woodward and Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, 140.

[741] Woodward and Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, 143.

[742] Freedman, *The Official History of the Falklands Campaign*, 726.

[743] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 61.

[744] Freedman, *The Official History of the Falklands Campaign*, 733.

other missiles such as the Sea Dart, Sea Wolf, and Sea Cat showed signs of the same exaggeration.[745] Later analysis which painstakingly accounted for all missile firings had different findings. First, the total number of Argentine aircraft shot down was reduced from 72 to 41.[746] Second, and partly as a result of the reduced total number of "kills," the performance ratios of all surface-to-air missiles was much lower. Only one known kill could be attributed to Rapier, potentially one to Sea Cat, and potentially two to Blowpipe.[747] Other "kills" may have been made by these missile types but the data was inconclusive due to numerous munitions being launched against the same target.

However, the true findings, which indicated that surface ships were still imminently vulnerable, were deliberately not publicized to maintain operational security.[748] While this was a prudent move, it may have obscured the harder questions about the continued reliance on aircraft carriers. The Falklands conflict was a limited test. The carrier-centric task force was able to accomplish its mission; however, had it been asked to move closer to Argentina to support raids on the main land air bases the story may have been different. Maintaining the carriers' positions at the maximum range of the Argentine bombers and not advanced missile defense systems had been the key to the success. In a combat scenario where that offset is not possible the carrier is the most attractive target at sea, inevitably a concentrated attack will at some point breach its defenses. Submarine performance in the Falklands offers a different perspective on sea power. The deployment of a mere three submarines was enough to keep the Argentine Navy in port—an effect in considerable disproportion to the numbers involved.

3. The First Gulf War

The fall of the Berlin Wall in 1989 provided a convenient historic bookend on the Cold War, but the seeds that brought it down were sown in the unrelenting and costly arms race, which had decimated the Soviet economy. The dust had barely settled from

[745] Freedman, *The Official History of the Falklands Campaign*, 733.

[746] Freedman, *The Official History of the Falklands Campaign*, 734.

[747] Freedman, *The Official History of the Falklands Campaign*, 733–734.

[748] Freedman, *The Official History of the Falklands Campaign*, 734–735.

the end of the Cold War when Iraq invaded Kuwait in August 1990. The American military was at its zenith, the techno-strategic foundations laid in the Second World War, nurtured, and maintained in spite of poor performance in Korea and Vietnam would be brought to bear in Iraq. Furthermore, Iraq was the aggressor and Saddam Hussein was a known "bad guy" which eased the strain of confrontation by facilitating the creation of a large international coalition. In November 1990 the UN Security Resolution 678 passed giving Saddam until January 15th to withdraw from Kuwait before "all necessary means" were used to enforce the resolution.[749] The stage was set for the buildup to begin—the first ships loaded with VII Corps equipment would begin arriving in Saudi Arabia on December 6th.[750]

Finally, the U.S. had found an enemy willing to go toe-to-toe in a conventional war, and the success of the coalition would be overwhelming—the U.S. had "licked the Vietnam syndrome once and for all."[751] During the war all of the familiar elements were present: large mechanized formations, carrier-centric naval deployments, and massive bombing campaigns. While on the surface, the task force composition resembled the same techno-strategic combination favored since the Second World War the technological advances in capabilities were significant. These familiar weapons systems had all been significantly enhanced by information age technology—computers, target acquisition system, satellite based navigation via Global Positioning Systems (GPS), secure resilient communications and precision "smart" munitions. All of the technological might would be brought to bear on the Iraqi Army. Intelligence estimates going into the war tended to grossly overestimated Iraqi strength. By January 1991 the estimates projected an army of nearly 540,000.[752] However, true strength was harder to qualify as many of the Iraqi soldiers—minus the elite Republican Guard—were poorly trained conscripts. Saddam did have a fairly good-sized, mostly modern, Soviet-

[749] Lawrence Freedman and Efraim Karsh, *The Gulf Conflict, 1990–1991: Diplomacy and War in the New World Order* (Princeton, N.J.: Princeton University Press, 1993), 234.

[750] Rick Atkinson, *Crusade: The Untold Story of the Persian Gulf War* (Boston: Houghton Mifflin, 1993), 509.

[751] President George H.W. Bush as quoted in: Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 493.

[752] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 341.

equipped air force and, as a result of the Iran conflict, robust air defenses.[753] There were concerns however, about Iraq's Scud missiles and about their potential willingness to use chemical weapons. Both had been used during the prolonged war between Iraq and Iran during the 1980s, and Saddam had even resorted to using gas against the minority Kurdish population within his own borders.[754] Still there was little doubt that the U.S. possessed a significant technological advantage.

The movement of that heavy technological advantage would take months, and by the end of the war 9,000,000 tons of equipment had been moved.[755] As noted earlier the first ships of VII Corps equipment began arriving in early December. The last units would not arrive until February, and even at the start of the ground war VII Corps was only at 80 percent strength.[756] The Iraqis used this time to strengthen their fortifications, but the delay of ground troops did not preclude offensive action from starting on the UN mandated deadline. The plan called for an air campaign prior to the ground offensive—given the decision to employ a heavily armored ground force it was the only offense available until VII Corps's equipment arrived.

The air campaign began on 16 January 1991 when a flight of B-52s—the strategic bastions of "massive retaliation"—took to the air on a round trip mission to Iraq.[757] The planes designed to deliver nuclear warheads were now carrying the latest compliment of precision GPS guided cruise missiles and 1,000 pound warheads.[758] Meanwhile, closer to the front, a massive aerial armada was taking to the sky. Stealth fighters loaded with laser guided munitions, aerial refulers, carrier-based aircraft, and a little over 100

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753 Freedman and Karsh, *The Gulf Conflict, 1990–1991: Diplomacy and War in the New World Order*, 281.

754 Freedman and Karsh, *The Gulf Conflict, 1990–1991: Diplomacy and War in the New World Order*, xxxii.

755 Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 493.

756 Freedman and Karsh, *The Gulf Conflict, 1990–1991: Diplomacy and War in the New World Order*, 287.

757 Richard Hallion, *Storm Over Iraq: Air Power and the Gulf War* (Washington: Smithsonian Institution Press, 1992), 163.

758 Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 163.

Tomahawk cruise missiles all began moving toward Iraq in hunt of their targets.[759] In the first day of the air-war 1,300 mission were flown.[760] Helicopters would also join the fray in a raid to knock out Iraqi radar capabilities making the job of the planes that much easier. Significant attention was paid to Iraq's aerial defense capabilities, as such, a full spectrum of electronic warfare measures were used to protect the armada, and to keep Saddam in the dark—losses to SAMs amounted to only 10 aircraft during the war.[761] The Iraqi Air Force was simply outclassed, engaging the coalition was akin to suicide that they even tried is a testament to their courage, however, they would not destroy a single coalition plane.[762]

Technologically enhanced targeting, from various satellite and plane based intelligence collection assets, made accuracy percentages skyrocket in some cases nearing 90 percent.[763] Monthly tonnage expenditures in the Gulf War rivaled those of the Second World War and Vietnam, but target selection and accuracy was far better, resulting in a greater effectiveness.[764] As Richard Hallion notes the air campaign targeted five areas: "command and control, power generation, refined fuel and lubricants production, the transportation infrastructure, and the Iraqi air force.[765] However, while the air campaign was formidable it was not decisive. Saddam was not killed nor did he withdraw from Kuwait, and there was no indication that it was the air campaign had destroyed the population's morale to the point of overthrowing Saddam. Furthermore, air power met with limited success in the hunt for Scud missiles, a key component of Saddam's strategy of provoking Israel to enter the war.

Dispersed and highly mobile Scud Missile launchers proved up to the challenge of evading one of the most technologically enhanced targeting and intelligence collection

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[759] Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 165.

[760] Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 166.

[761] Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 172.

[762] Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 175.

[763] Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 177.

[764] Monthly totals were: 47, 777 in WWII, 44,014 in Vietnam, and 40,416 in the Gulf War Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 190.

[765] Hallion, *Storm Over Iraq: Air Power and the Gulf War*, 190.

efforts of modern war. Saddam had invested heavily in the Scud missile during the prolonged Iran-Iraq war. Scud attacks became an enduring feature of the "battle of the cities" in which both Iran and Iraq fired Scuds into each other's centers of population.[766] With no onboard targeting the Scud was primarily a terror weapon. Saddam intended to use it precisely in that fashion. Within 36 hours of the start of the air campaign the first Scuds began falling on Israel.[767] It was a calculated move by Saddam to provoke Israel to retaliate, with the endgame being to fracture the coalition. The Israelis were too savvy to take the bait. However, had the Scud had been a more capable weapon system; the limitation of air power to destroy a dispersed mobile force might have had a larger impact. Especially given that, in retrospect, the faith of the coalition in its missile defense provided by the Patriot (Anti-Ballistic Missile) ABMs was unfounded.

Other approaches to hunting Scuds existed. Major General (later General) Wayne Downing, an Army Ranger and commander of the Joint Special Operations Commander (JSOC), had a plan to insert the Army's Delta Force in a ground-based Scud hunting role.[768] The Special Air Service (SAS), a British Special Operations Forces (SOF), was already in Iraq doing precisely what Downing was proposing, but yet the administration hesitated to send in Delta. General Norman Schwarzkopf was largely against SOF employment, and was resistant to any SOF proposal that may have interrupted the ground campaign.[769] Nevertheless, when the Scuds kept falling JSOC was eventually sent to Iraq. Commitment to their operations from Schwarzkopf was never high, but even with the limited allocation of resources the pressure that the combined efforts of the SAS and JSOC reduced Scud attacks from five a day to one a day.[770]

Advancements in technology had not occurred solely in the realm of air power. Technological improvements abounded. The U.S. main battle tank the M1A1 Abrams, named for the MACV commander that replaced Westmoreland, could reach speeds up to

[766] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 145.

[767] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 81.

[768] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 142–143.

[769] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 180.

[770] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 179.

45 MPH, had Chobaham armor plating capable of surviving a hit from its Soviet competitors, and a 120mm main gun capable of firing a depleted uranium tank-killing round over two and half miles.[771] The M1A1 other advantages included a stabilized main gun barrel which made accurate firing while moving a possibility, laser range finders, computerized targeting, and night vision thermal sights.[772] The American Army, in its heavy divisions had maintained its commitment to full mechanization, a critical feature to logistically sustaining an armored offensive. On the morning of February 24, 1991 the ground offensive began—it would end four days later.

One on the first assaults of the first day was a 93-mile, helicopter-borne assault into enemy territory to seize key terrain for future offensive staging conducted by the 101st Airborne Division.[773] The 101st was essentially the 1991 version of the Vietnam era airmobile concept; however, once again the process of evolutionary development had its effects. Helicopters enhanced with information age, computer assisted avionics packages could fly low and fast over the terrain mitigating some of the vulnerability they had shown in Vietnam. Furthermore, attack helicopters, such as the AH-64 Apache were moderately armored against small arms, and when equipped with the latest offensive weapons could perform suitable in both an anti-personnel or anti-tank role. Still though helicopters present challenges for logisticians, they are difficult to maintain especially in a desert environment and unlike a mechanized formation cannot carry everything they need for a sustained offensive effort—eventually they have to return to base to refit and refuel.

The U.S. Army's enduring commitment to the heavily mechanized paradigm of massed fires and offensive maneuver was on full display as the coalition executed the famous "left hook" through the desert of southwest Iraq. In an artillery barrage that rivaled the British preparatory fires on the Somme in 1916, the U.S. barrage of rockets and shells totaling 11,000 rained down on the Iraqis over the course of a half hour.[774]

[771] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 329–330.

[772] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 330.

[773] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 342.

[774] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 343.

The fear of taking casualties was replaced with the growing issue of what to do with all the prisoners. Indeed the mass surrenders were one of the most memorable features of the war, and one that had potentially brought about by one of the cheapest “bombs” in the war—2,800,000 propaganda leaflets had flittered their way into Iraqi hands during the air war.[775] The M1A1 Abrams superiority was decisively demonstrated in a battle between the 2nd Armored Cavalry Regiment and the Tawakalna Division—one of the vaunted Republican Guard units—during the battle of 73 Easting hundreds of Iraq’s vehicles would be destroyed in hours.[776] The “left hook” was wildly successful; the ground war was over so quickly that it hardly seemed real.

The victory resulting from the combination of a targeted air campaign in support of an eventual ground invasion showcased the technological might of the U.S. led coalition. However, prowess in this war was not a result of technology alone. Vietnam had impacted the army fundamentally, and the officers who stayed the course at its conclusion had rebuilt the army. Besides cleaning up the rampant discipline problems the U.S. military in general had overhauled its training and doctrine. The creation of large training area such as the National Training Center (NTC) in Fort Irwin CA and the Fighter Weapons School at Miramar Naval Air Station in San Diego CA provided a training environment that could replicate the conditions of war.[777] Units scheduled to participate in a “rotation” at the NTC would train-up for the event at their home station, and then deploy to CA to participate in a structured war game that involved a dedicated U.S. Army unit to play to role of opposition force. The ability to experience simulated war of this quality using the same technology it would use in actual war went a long way towards the development of doctrine. AirLand Battle emerged as the overarching Army doctrinal framework in 1982.[778] It was a doctrine designed for the plains of Europe. Accordingly, it exhibits the prevailing preferences of the time for mechanization and air power used in concert to destroy the enemy ground force through rapid offensive

[775] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 341.

[776] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 345.

[777] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 332.

[778] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 252–253.

maneuver and aerial attacks on their rear areas. The familiarization of doctrine and technology provided through the realistic training environment at venues like the NTC went a long way towards the integration of technology and strategy. Iraq's rapid capitulation seemed to confirm the techno-strategic decisions made following the Vietnam War. However, was that the correct inference to draw?

Air power's apparent prowess had once again captured the American imagination; the combination of informational technology had finally seemed to crack the code to make air power the decisive arm of American policy. But airpower had not achieved all of it objectives in the Gulf. It had not killed Saddam or generated enough angst to start a rebellion, it had not been able to destroy the mobile Scuds, and it had not destroyed the Iraqi Army. Soon (1999) the all-air-power approach seemed to get further empirical support in Kosovo, but in that campaign too it was the combination of air power, diplomatic overtures from the Russians, and the credible threat of a ground invasion that forced Milosevic to surrender not solely air power.[779]

The Gulf War had not been a naval war, however, as the only show in town it was supported with multiple carriers groups. By and large the carriers only served to increase the amount of aircraft participating in the war, although the navy did enact an effective blockade. The fears of anti-ship missiles, and mining played a role in keeping the carriers well off the coast. The mine sweeping ships needed for the larger job of supporting a Marine amphibious landing in Kuwait, known as Desert Saber, had been neglected by the U.S. during the cold war.[780] As the planning for the assault continued the time table for its execution kept extending—eventually the amount of time to prepare the sea infiltration routs and beachhead plus the amount of destruction that preparation would inflict onto Kuwait was deemed untenable.[781] Desert Saber was canceled although the

[779] Ivo H. Daalder and Michael E. O'Hanlon, *Winning Ugly: NATO's War to Save Kosovo* (Washington, D.C.: Brookings Institution Press, 2000), 202–203.

[780] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 237.

[781] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 239.

appearance of a potential amphibious landing was maintained as a feint to keep the Iraqis' tied to their costal defenses.[782] The battleship also made its last American combat appearance in the Gulf providing naval gunfire.

The Army emerged from the desert as the apparent master of ground combat, but again there are tough questions to ask about this "test" of techno-strategy. First, Saddam employed his forces in a conventionally modeled defense—the exact type of defense the American's modeled their force to defeat. Second, although seemingly large, Iraq's army was a hollow shell. Saddam's soldiers simply did not want to defend to the last man. Third, the desert terrain was entirely favorable to the American's technological suite of targeting, and navigation tools—had the war aims not remained so narrowly defined and the war had moved into the cities the victory may not have been so clean. However in spite of all these advantages, the mobility of the Saddam's Scud force proved elusive until the very end. The generals had done a magnificent job during this war keeping the civilian objectives within the province of its advantages. Having resolved to never fight another Vietnam the generals narrowly defined the conditions for the application of force, and then ensured that they had what they needed to accomplish their limited objectives. Had the Bush administration pushed for a more rapid response, or made the decision to pursue Saddam into the cities what would have happened? Furthermore, the army took many months and required 9,000,000 tons of equipment and 550,000 troops to do the job the way they wanted—this approach may have gotten results, but it is too cumbersome and blunt to be effective across a broader range of circumstances. If any lesson was to be learned from the Gulf War, it was that fighting the U.S. in a conventional manner was not tenable.

C. SUMMARY

The Second World War significantly impacted the national consciousness. The allies emerged as the unqualified victors. The U.S. military largely attributed the victory to bombing, carrier-centric naval battle, and fully mechanized land forces. Furthermore, the creation and use of the atomic bomb seemed to offer a technological solution that

[782] Atkinson, *Crusade: The Untold Story of the Persian Gulf War*, 239–240.

would radically alter the way war was fought. The fight over who would deliver the atomic bomb, and the creation of an independent U.S. Air Force both exacerbated post-war civil-military relationship and may have served to confuse analysis over the most effective techno-strategy. As the World War receded and the ideological struggle against communism increased America was drawn into more limited wars to contain communism. In Korea American got its first taste in fighting post-atomic limited wars. Many had assumed that atomic weapons would be used, when they were not the military was confronted with its inadequate preparedness. MacArthur was able to turn the war around after successfully pushing for the landing at Inchon. However, the victory at Inchon expanded the aims of the war. In spite of evidence that the Chinese were about to intervene, MacArthur pushed north toward the Yalu River. When the Chinese did enter the war the American's were spread too thin to mount an adequate defense, and suffered accordingly. The entrance of the Chinese expanded the scope of the war and MacArthur wanted the authorities to fight them in the way he knew best—a strategy of total war. Truman, however, did not agree with expanding the war and showed restraint as the lines entrenched along the 38th parallel.

Eisenhower offered a "new look," first in Korea where the implicit threat of nuclear war may have facilitated the armistice but also towards a techno-strategy of massive retaliation. It was strategy without nuance or utility, but it did serve to further entrench organizational preferences. Technologically the strategy of massive retaliation exerted evolutionary effects. The technological archetypes used to deliver atomic weapons—planes, submarines, and missiles—all made steady performance gains. However, there is a second technological story that emerged from the Second World War. Information technology became increasingly sophisticated and ubiquitous—militaries enabled by information technology whether as a component of "smart" munitions, or underwriting a responsive architecture for command and control would operate a blinding combination of speed and lethality.

As the Cold War continued in to the Kennedy administration the was the recognition of the need for a more "flexible response." Kennedy's proactive involvement in civil-military affairs started to make inroads into changing the military; however, his

tragic death occurred too soon. The continuing conflict in Vietnam, and the incremental increases of American involvement would soon accelerate under Johnson after the Gulf of Tonkin incident. Westmoreland would prove a zealot of the World War industrial age paradigm of warfare. His continued support for a duly focused strategy of strategic bombing and helicopter enabled search-and-destroy operations would bring 550,000 troops to Vietnam in 1968 for little gain. Fundamentally it was a failure of understanding that the war was not a completion for terrain or a battle of attrition but was instead a battle for the population. Other contemporary strategies recognized this—the CAPs being one example. One of the biggest failures of Vietnam was the failure to learn. Of course, credit must also be given to the North Vietnamese. Their strategy, which blended guerrilla insurgents and conventional forces, was skillfully employed to maximize the strengths of dispersion and anonymity. Their success, against first the French and later the U.S., provided a powerful example of the limits of technological superiority.

While Korea and Vietnam may have defined the hot aspects of the Cold War for America, the period following the conclusion of the Second World War saw numerous other conflicts. Two conflicts in particular pose interesting questions for techno-strategic preferences of the West. The continuing conflict (studied in this chapter from 1956–1973) between Israel and its Arab neighbors provides a useful comparison to Vietnam since both occurred during roughly the same time. Israel built its army along heavily armored lines, approaching at times an almost exclusively armor based force. The armored land forces were complimented by a strong IAF that emphasized CAS. When the indicators pointed to war in 1967 Israel executed a preemptive attack that destroyed the bulk of the Egyptian Air Force, and made rapid territorial gains. Israel had won a significant victory, and the technologies associated with took on an ever larger centrality in Israeli military strategy. But in defeat the Egyptians, with the support of their Soviet allies, reflected on their approach to countering Israeli armor. By dispersing small teams armed with shoulder fired ATGMs in ambush positions along likely avenues of approach the Egyptians reasoned that they could neutralize some of the Israeli's armored advantages. This approach would ultimately not be enough to secure victory, but it did significantly change the perceptions of Israeli invulnerability.

The course of the combat in the Falklands War in 1982 is important to look at because of its potential implications for a carrier-centric navy. Three things stand out in this conflict:

1. The vulnerability of surface ships to aerial munitions.
2. The relatively low success ratio of missile-based, anti-aircraft defense.
3. The role of submarines in preventing the Argentine Navy from joining the fight.

The first two pose questions regarding the logic for the continuing emphasis of a carrier-centric force, while the latter provides the hint of an alternative approach.

The final American adventures of the period—the First Gulf War and the NATO intervention in Kosovo conclude the period. The advances in the weaponry that had occurred during the period since the conclusion of the Second World War were astounding. Smart, informational enabled, munitions were used to good effect in a preliminary air campaign to attrite the Iraq military and logistical infrastructure in preparations for a ground offensive. When it finally commenced the ground offensive, again showing the superiority of an informationally enabled military, was short and overwhelmingly lopsided. However, under the surface of the victory there were some problems. First, the response was neither timely nor efficient. Second, Saddam, forced to hold the terrain in Kuwait, chose to array his forces in the conventional order of battle that the U.S. techno-strategy had been designed to fight—against the mobility and dispersion of the Scuds the results were more mixed. Third, the military and political safeguards to prevent the expansion of the war could be viewed pessimistically as an admission that the military was not prepared to take the fighting into urban Iraq where its advantages would not be as clear. But the First Gulf War is also interesting in that for all the advances in technology the fighting was in many respects reminiscent of the Second World War.[783] Information technology clearly enhanced the capabilities of the U.S.

[783] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 38.

military in the application of the industrial age paradigm that emerged from the Second World War, but it is critical to ask whether information technology had reached the point where it could engender a new paradigm.

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VI. 9/11 AND BEYOND: RECOMMENDATIONS FOR AN INFORMATION AGE TECHNO-STRATEGY

"'The world has [changed]—and we have not yet changed sufficiently. The clearest and most important transformation is from a bipolar Cold War world where threats were visible and predictable, to one in which they…are impossible to know today'"[784] Over a decade into the twenty-first century what can we say about the current state of techno-strategic integration in the U.S. Military? Before answering that, though, consideration must be given to an analysis of what the current threat environment entails. Although the events of 9/11 were certainly sobering, they are often overly emphasized. Terrorism as a tactic has existed for ages. Indeed, suicide terrorism has been in the rise for at least two decades.[785] However, the successes in the execution of suicide terrorism, as in the case of 9/11, almost certainly ensures that the technique will continue to be imitated.[786] Information age technology has enabled the networking of enemy organizations, but it has also in some sense revitalized older organizational heritages, in the case of al-Qaeda, as noted by David Ronfeldt, it has facilitated "virulent tribalism."[787] Terrorism, and suicide terrorism, however, is just a component of the larger adversarial techno-strategy of America's recent enemies—one that plays on a familiar dichotomy of dispersion vs. mass that has been identified periodically as an undercurrent through this study. Furthermore, looking back to Giap's concept of operations in Vietnam where the paramilitary VC were capable of engaging in guerrilla style attacks or coalescing for more traditional military operations supported, in the case of Vietnam, by the NVA. This concept of operations could be extended to support a three pronged strategy of, terrorism, guerrilla or insurgent operations, and when the conditions merit it, more conventionally

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[784] Secretary Donald Rumsfeld 10 September 2001 as quoted in: Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 361.

[785] Robert Anthony Pape, *Dying to Win: The Strategic Logic of Suicide Terrorism*, 1st ed. (New York: Random House, 2005), 5.

[786] Pape, *Dying to Win: The Strategic Logic of Suicide Terrorism*, 22.

[787] David Ronfeldt, "Al-Qaeda and its Affiliates A Global Tribe Waging Segmental Warfare," in *Information Strategy and Warfare*, eds. John Arquilla and Douglas A. Borer (New York: Routledge, 2007), 44.

styled operations—none of which require a centralized standing military. Hezbollah is a modern organization that may represent this strategy. Furthermore, Hezbollah's proxy relationship with Iran makes targeting even more difficult. Iran has in some sense figured out how to fight non-attributable warfare. The proliferation of weapons, some of which have been innovatively repurposed to better support a guerrilla techno-strategy, ensures that the access to weapons will continue for those willing to fight, especially as states look towards concepts of operations along proxy lines. The networked organization, emphasizing lateral linkages to facilitate rapid, decentralized lateral decision making, has become and will continue to be central to a strategy that seeks to maximize dispersion.[788]

The U.S. military's dominance of the industrial age techno-strategic paradigm of warfare that emerged fully integrated at the conclusion of the Second World War, and was then significantly enhanced by the development of informational age technology, has forced our enemies to look to strategies that offset our advantages. While it is true that our adversaries have proved to be the more adaptive to emerging networked organizational forms, there is no reason to conclude that innovations in information technology cannot be techno-strategically integrated into a reoriented U.S. military. The major difference between the U.S. techno-strategic approaches to integrating information age technology is that it was overlaid on top of the existing organizational preferences, whereas elsewhere it enabled new or reimagined forms of warfare. Looking at the recent wars in Iraq and Afghanistan may provide an indication of how far the U.S. military has come and what remains to be done.

A. INNOVATION UNDER FIRE

Innovating under fire is a central theme of techno-strategic integration. It is true that "you go to war with the Army you have," but it is also true that the army you have will not be the same at the end of a conflict.[789] Looking at some of the experiences from

[788] John Arquilla and David F. Ronfeldt, "The Advent of Netwar," in *In Athena's Camp: Preparing for Conflict in the Information Age*, eds. John Arquilla and David F. Ronfeldt (Santa Monica, Calif.: Rand, 1997), 277.

[789] William Kristol, "The Defense Secretary we have," *Washington Post*December 15, 2004.

the last decade of combat offers examples for consideration as the military moves toward an information age paradigm. Summarizing and making sense of so much recent history is too broad a task, therefore, a more selective sampling will be used to highlight “the good,” “the bad,” and “the ugly.”

1. The Good

There have been numerous examples during the last 10 years of war that can be cited as “the good.” Two will be quickly highlighted, the opening of Operation Enduring Freedom, and the innovated technological work being done in the field of drones and robotics. The implications of “the good” features of the war must be carefully considered as offering a glimpse into techno-strategy as it may come to be.

The opening phase of Operation Enduring Freedom offers one of the clearest examples of what a new concept of operations within the informational paradigm might entail. Against significant organizational resistance from the Army, Secretary of Defense Donald Rumsfeld was able to put boots on the ground in Afghanistan on 19 OCT 2001.[790] The Special Forces teams linked up with their Northern Alliance counterparts and devised a concept of operation that used the local knowledge of the friendly Afghani’s to help locate the Taliban positions. From horseback the Special Forces called in the satellite guided bombs. It was a juxtaposition of the agricultural and the informational—and it was effective. It also showcased the best use of airpower. The bombing campaign, which had begun on 7 October, transformed from an ineffectual show of force to a lethal campaign against Taliban targets once boots were on the found to provide real time locally informed intelligence.[791] Furthermore, this concept of operations indicates the possibilities of a techno-strategy that best maximizes the information advantages in communications and precision munitions while limiting the overt presence. The military should look to this paradigm and try to operationalize it on a broader conceptual level. This operation was conducted by Special Forces, but there is

[790] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 40–41; Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 352.

[791] Boot, *War made New: Technology, Warfare, and the Course of History, 1500 to Today*, 367.

no reason why a permutation of this style of operations could not be diffused throughout the military to support a "super-sized" version of the same concept of operations within the General Purpose Force (GPF). Having the ability to employ a similar style of operations but with a larger force could be a way to unshackle ground operations from its current logistically intensive mechanized formula.

Another example of "the good" is the innovation that has taken place in the development and employment of drones. Like the helicopter in Vietnam the Unmanned Aerial Vehicles (UAVs), may well emerge as the iconic technology of the "Global War on Terrorism." UAVs may also only be the tip of the iceberg in a larger robotic revolution. The robot industry has made tremendous strides in improving robotics technology during the GWOT, and that has translated into increased demand[792] UAVs and robotics represents the leading edge of technology. However, it would be wrong to assume that the U.S. has monopoly on the technology. China has a well-developed robotics industry, and a keen interest in developing technological solutions to countering perceived American advantages.[793] The potential for diffusion is virtually unlimited, and the variations of the theme virtually limitless, in one case Hezbollah used a combination UAV and Improvised Explosive Device (IED) against Israel.[794] However, as shown in this study, having the technology is only one side of the story. It is the integration of the technology into a strategy that best makes best use of it that confers advantages. Joint Special Operations Command (JSOC) in particular has done a good job of integrating drones, as one of many elements, into an overarching techno-strategy. JSOC blends dispersion with mobility and the ability to concentrate forces to apply pressure on enemy network through leadership targeting. Furthermore, JSOC has pushed the envelope within the military to flatten its organization and increase its decentralization. JSOC may offer a model for imitation within the military to make use of some of its best organizational practices.

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[792] P. W. Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century* (New York: Penguin Press, 2009), 23.

[793] Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century*, 246–247.

[794] Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century*, 264.

2. The Bad

If the approach at the beginning of Afghanistan serves as an example of "the good" then the approach to the invasion of Iraq can be used as an example of "the bad." For the purposes here the focus will be exclusively on the techno-strategy of the invasion in 2003, and will not focus on the dubious road to war. The invasion of Iraq offers a differing interpretations depending if it is compared to either the First Gulf War or the Special Forces action in OEF. Compared against the former, the invasion in Operation Iraqi Freedom (OIF) is a model of paucity. There were no significant bombing preliminaries as compared to the First Gulf War. The ground force for the invasion only totaled 145,000 troops, a significant reduction from the First Gulf War.[795] However, compared to Afghanistan the numbers seem excessive. Indeed, there was some consideration for an approach similar to the one employed in Afghanistan whereby between 25,000 and 50,000 troops would be employed with supporting air coverage, but this approach was discounted.[796] However, the chosen strategy was too heavy to minimize the amount of gratuitous destruction, and too light to control the population. Saddam had learned from the First Gulf War, and the U.S. military was not going to be able to limit its objectives to the deserts of the southern Iraq. Interestingly the majority of the debate inside the military focused on the need for more troops while Secretary Rumsfeld pushed for less.[797] Furthermore the ensuing insurgency was cited as proof that the military had gone in too light—perhaps it is time to question whether they had gone in too heavy. A smaller Afghanistan-styled operation, may have limited the amount of destruction done during the opening phases of the ground campaign, and it would have certainly reduced the visibility of the coalition—both might have reduced the growing Iraqi angst.

The second element of "the bad" is in some ways related to the first, and importantly, is an unavoidable consequence of continuing to operate using the industrial

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[795] Thomas E. Ricks, *Fiasco: The American Military Adventure in Iraq* (New York: Penguin Press, 2006), 117.

[796] Arquilla, *Worst Enemy: The Reluctant Transformation of the American Military*, 89.

[797] Ricks, *Fiasco: The American Military Adventure in Iraq*, 119–120.

age techno-strategic paradigm. Heavily mechanized land forces supported by a vast array of planes and helicopters require extensive logistical and support capabilities. As in Vietnam, the support forces deployed compared to the forces actually involved in the fighting is skewed heavily in favor of support. The requirement to feed and house the support personnel necessary to make the industrial age paradigm work is one of the biggest detractors of the approach. The large, well-equipped bases that spring up inevitably draw attackers and cause resentment, making tighter security necessary. A distributed information age approach will need a new approach to logistics, and the military needs to adjust to operating without the creature comforts found on the largest bases. Not only will this save costs but it will facilitate appearances. Reducing the total numbers living on the large bases would have reduced the number of incidents along the roadways, and together with an increased use of aerial logistics delivery may have gone a long way towards reducing target availability for IEDs.

Information technology may give the military new tools to solve its "footprint" problem. But it is also time to ask whether it is still necessary to deploy division and corps headquarters? The tools of the information age have made it possible for command and control at the level of analysis represented by division and corps headquarters to be performed from the U.S. Making this change will require no less than a transformation of military culture, which rightfully still emphasizes leadership from the front. However the cost of supplying that leadership at the division and corps level has become too high. Certainly, attention must be given to preventing a new instantiation of *château* generalship, but information age technology is up to the tasks

3. The Ugly

What about "the ugly"? How has information age technology made us vulnerable? One area that has received growing attention, although not necessarily grounded in actual events, is cyberwarfare or cyberterrorism. In either case the idea is that a technologically savvy adversary would, through surreptitious means, gain access to a vital computer system and then compromise it to either gain an advantage or to degrade

the victim's capabilities.[798] However, Gabriel Weimann points out that there has not yet been a successful cyberattack.[799] Still capabilities and vulnerabilities are linked and this is an area that must be paid due diligence as the military transitions to the information age paradigm.

The information age can also conflate the traditional rank-to-impact linkage. The last decade has witnessed the impact of both the "strategic corporal" and the "tactical general."[800] Abu Ghraib quickly showed the impact of the strategic corporal. But the overcrowding of the prison system in general was a direct result of the heavy-handed conventional approach the U.S. military employed. Similar to "body counts" in Vietnam in Iraq the metric of success was captures "hundreds of raids were conducted and over ten thousand Iraqis were detained."[801] Prison systems across the country were holding well in excess of their capacity. It was only a matter of time, at Abu Ghraib and in numerous other incidents prisoners started being abused.[802] At Abu Ghraib, however, there were pictures of the humiliation, and when they hit the news the war changed. The Iraqi insurgency had its rallying cry—one instance of the impact of the strategic corporal.

The impact of the tactical general is no less insidious. Information technology makes information rapidly available, but it is organizational structuring that determines who has access to it and is able to act on it. The availability of real-time information combined with the ability to communicate across the battlefield allows the tactical general to centralize decision making and micromanage subordinates to unprecedented levels.[803] This is clearly not an effective approach to information age operations. The general has more access to information than ever before, but the amount of time in the

798 Gabriel Weimann, *Terror on the Internet: The New Arena, the New Challenges* (Washington, D.C.: United States Institute of Peace Press, 2006), 147–171.

799 Weimann, *Terror on the Internet: The New Arena, the New Challenges*, 164.

800800 P.W. Singer attributes the phrase "strategic corporal" to General Charles Krulak in 1999. See P. W. Singer, "Tactical Generals: Leaders, Technology, and the Perils of Battlefield Micromanagement*," *Air & Space Power Journal* 23, no. 2 (Summer 2009, 2009), 78.

801 Ricks, *Fiasco: The American Military Adventure in Iraq*, 199.

802 Ricks, *Fiasco: The American Military Adventure in Iraq*, 270–297.

803 Singer, *Tactical Generals: Leaders, Technology, and the Perils of Battlefield Micromanagement**, 80.

day has not increased. Information age commanders will need to achieve a balance between staying connected and interjecting.[804] The analysis of "the good," "the bad," and "the ugly" potentially illustrates some of the features of the current state of techno-strategic integration. However, these current examples do not offer any insight into the factors facilitating or inhibiting further techno-strategic integration.

B. PARADIGM SHIFT: THE INFORMATION AGE TRANSITION TO A NEW PARADIGM

Identifying a techno-strategic paradigm shift is difficult. The few examples of military organizations getting it right speaks to the difficulty of integrating revolutionary technologies. However, there are usually individuals or sub-groups who recognize the implications before the majority. This study has shown some common impediments militaries have encountered when grappling with new technologically viable concepts of operations. Foremost among these is organizational preference. The military, at least for the foreseeable future, will remain hierarchical and bureaucratic. This need not necessarily be viewed pejoratively, but it is also true that hierarchical organization contributes to the problems of organizational preference. The leaders at the top of the organization may be too wedded to the techno-strategy that informed their experience and training as a younger officer to see the new techno-strategic possibilities. The general worldwide failure to break with battleships following their uninspiring performance in the First World War stands out as one of the best examples of the deleterious impacts of organizational preference.

Numerous examples of senior leaders that did not fall prey to this trap exist—Nathan B. Forrest, Karl Dönitz, Charles Lockwood, William Moffett, and Maxwell Taylor—are a few examples of senior leaders who were able to identify the changing techno-strategic potentialities. Significantly, none were able to enact a sweeping techno-strategic reorganization; their role in some sense was more heraldic. The example of interwar Germany also stands out. The German military made significant strides toward techno-strategic integration in spite of the restrictions of the Treaty of Versailles. Central

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[804] Singer, *Tactical Generals: Leaders, Technology, and the Perils of Battlefield Micromanagement**, 83.

to that success was the distillation of talent due to military downsizing, and a rigorous examination the lessons of the First World War. However, in light of the progress the Germans made it is in some ways more surprising to consider what they missed. The German Navy did not emphasize the submarine despite their success with it in the First World War. They did not appreciate the advantages of fully mechanizing their ground forces, and they failed to appreciate the capabilities of a four-engine bomber. Organizational preference is, and will continue to be, an obstacle to recognizing techno-strategic possibilities. Acknowledging that it exists is probably one of the most progressive steps towards alleviating its effects. However, civil-military relations informed by active political participation are also essential. Civilian leaders cannot abdicate responsibility for shaping the military; however, care must be taken by the military to ensure that politicians are adequately informed.

Moreover, strong civilian leadership is necessary to prevent inter-service rivalry from corrupting objective service self-assessment. Inter-service rivalry tends to reinforce existing organizational techno-strategic preference. When a rival services questions the techno-strategy of its fellow services the tendency is for the impugned service to close ranks in support of its defining techno-strategic capabilities. Inter-service rivalry also exerts its effects on techno-strategy by causing services to favor the approach that provides the most autonomy. The creation of independent air forces and its relationship on the subsequent emphasis of the mission of strategic bombing is the example that best highlights this obstacle.

One final obstacle to enacting a techno-strategic paradigm shift comes from industry. Security represents and increasingly large field and private contracting has become one of features of modern war. Support firms such as Brown & Root have become so central that large scale military operations have become that conjoined to their logistics support.[805] Furthermore, private security firms recruit heavily from the ranks of retired senior officers and noncommissioned officers making collusion with former

[805] P. W. Singer, *Corporate Warriors: The Rise of the Privatized Military Industry* (Ithaca: Cornell University Press, 2003), 137.

colleagues a real potential.[806] Problematically this may impede techno-strategic shifts. These firms represent one more interest that must be considered when identifying the resistance or acceptance of new techno-strategic possibilities.

Identifying some of the obstacles is helpful. But what can be said about facilitating techno-strategic shifts? First the military needs to create an environment tolerant of experimentation and intellectual diversity. During the interwar period the U.S. Navy conducted some true experiments with aircraft carriers during their fleet war games, while the question was not decisively decided in the favor of carriers it created alternative courses of action for the U.S. Navy after to loss of the battleship fleet during Pearl Harbor. Also at the NTC following Vietnam, the Army was able to test its AirLand Battle doctrine in conditions approximating real combat. The U.S. military should continue to seek out opportunities to test new techno-strategic concepts. However, to create an environment where true experimentation with techno-strategic concepts is encouraged commanders will have to be able to "fail" without suffering major career setbacks. Second, support to firms such as DARPA continues to represent a sound investment strategy.

As the requirements of the GWOT recede and the defense budget is adjusted, the U.S. military is in good position to put greater emphasis on recasting its techno-strategy. There is a wealth of experience in the current military that must be oriented toward extrapolating lessons from its history and pushing new techno-strategic frontiers. Enemy organizations will continue to adapt, but the deliberate cultivation of technological development coupled with an environment conducive to experimentation will greatly contribute to the integration of technology and strategy.

[806] Singer, *Corporate Warriors: The Rise of the Privatized Military Industry*, 120–121.

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